Jesse/or Library.

ALTERNATIVE FUTURES FOR PHILADELPHIA'S COMMUTER RAIL SYSTEM

AFL
~~Jesse~~
Tim — NICE!
Peter Bromley's
final team project at
Penn. FYI
+ return
RBB

Regional High Speed Transit Consortium

ALTERNATIVE FUTURES
FOR PHILADELPHIA'S COMMUTER RAIL SYSTEM

John Allen
Joseph Augustyn
Carmen Blassini
Peter Bromley
Scott Gibbons
Mehdi Hitewesh
Jaime Martinez
Aurelio Menendez

May 1983

Instructor: Prof. Anthony R. Tomazinis
Department of City and Regional Planning
University of Pennsylvania

This study is submitted in partial fulfillment of the requirements for the degree of Master of City Planning as stipulated by the Department of City and Regional Planning, Graduate School of Fine Arts, University of Pennsylvania.

TABLE OF CONTENTS:

Page

Introduction i

Chapter 1 : The Commuter Rail System in the Philadelphia Metropolitan Region 1

1.1 Introduction 1

1.2 Development of Commuter Rail in the Region. 2

1.3 The Existing Commuter Rail System. 10

1.3.1 General Overview of the System. . . . 10

1.3.2 Detailed Description of the Sytsem. 13

1.3.2.1 The Reading District Lines . . 13

1.3.2.2 Philadelphia District Lines. . 18

1.3.2.3 The Airport High Speed Line. . 22

1.3.3 Terminals 24

1.3.4 The Center City Commuter Connection. 25

1.3.5 Stations and Parking. 27

1.3.6 Track and Station Ownership 31

1.3.7 Track Characteristics and Conditions. 32

1.3.8 Signal System 37

1.3.9 Electric Traction Power 39

1.3.10 Rolling Stock 41

1.4 Commuter Rail Services, Cost, Financing and Manaagement. 43

1.4.1 System Ridership and Level of Service. 44

TABLE OF CONTENTS (Continued)

Page

1.4.2 Commuter Rail Fares 48

1.4.3 System Operating Costs and Financing 49

1.4.3.1 Operating Costs. 49

1.4.3.2 Operating Revenues and Subsidies. 51

1.4.4 System Capital Costs and Funding. 55

1.4.5 System Management. 59

1.4.6 Problems with the Existing Commuter Rail System 62

References - Chapter 1 65

Bibliography - Chapter 1 66

Chapter 2 : Land Use 68

2.1 Land Use - Transporatation Alternatives 68

2.1.1 Development Scenarios 69

2.1.2 Land Use - Transporation Combinations. 71

2.2 Regional Land Use. 79

2.2.1 Regional Development Plan: Multi-purpose Centers Concept 79

2.2.2 Categories of Urban Centers and Criteria for their Selection 80

2.2.2.1 First Category: The Metropolitan Center. 81

2.2.2.2 Second Category: Regional Centers 83

TABLE OF CONTENTS (Continued)

Page

2.2.2.3 Third Category : Sub-regional Centers 84

2.2.3 Relationship between the Multi-purpose Centers and the Regional Rail System. 86

2.3 The Multi-purpose Center as a Development Alternative. 89

References - Chapter 2. 92

Bibliography - Chapter 2. 93

Chapter 3 : Alignment and Technology of Alternative I and Alternative II 94

3.1 Alignments 94

3.1.1 Introduction. 94

3.1.2 Methodology 97

3.1.3 Alternative I : Modernized System . . 98

3.1.4 Alternative II : Expanded System. . . 104

3.2 Technology 117

3.2.1 Station Design. 118

3.2.2 Fare Collection 120

3.2.3 Rolling Stock 127

3.2.4 Track and Power 133

3.2.5 Signalling and Communications 135

Bibliography - Chapter 3 139

TABLE OF CONTENTS (Continued)

Page

Chapter 4: Stations 141

4.1 Station Selection Process 141

4.2 Station Upgrading 143

4.3 Potential New Station Locations 150

4.4 Station Design Requirements 160

4.4.1 The Passengers 161

4.4.2 The Operating Agency 162

4.4.3 The Community. 162

4.5 Prototype Station Designs 163

4.5.1 The High-Density Development Station. 165

4.5.2 The Low-Density Development Station. 166

4.5.3 The Employment Development Station. 167

4.5.4 Park & Ride Stations 170

Bibliography - Chapter 4 170

Chapter 5: Joint Development Opportunities. 171

5.1 Overview. 171

5.2 Historical Approach 172

5.3 Lessons Learned 174

5.4 Proposal. 177

5.5 Constraints 181

TABLE OF CONTENTS (Continued)

Page

Chapter 6: Operations 183

6.1 Introduction. 183

6.2 Summary 184

6.3 Intermodel Connections. 184

6.4 Marketing 187

6.5 Information Systems. 191

6.6 Security and Safety. 193

6.7 Labor. 194

6.8 Scheduling 201

6.9 Conclusion 208

References - Chapter 6. 210

Bibliography - Chapter 6. 211

Chapter 7 : Fare Structure 212

7.1 Existing Fare System 212

7.2 Evaluation of Existing Fare System. 215

7.3 Proposed Fare System 218

7.4 Fare Revenues. 223

Bibliography - Chapter 7. 226

Chapter 8 : Ridership. 227

8.1 Purpose and Scope. 227

8.2 First Round Ridership Model. 229

TABLE OF CONTENTS (Continued)

Page

8.3 Construction of Final Ridership Model. 230

8.3.1 Methodology. 230

8.3.2 Model Adjustment Assumptions . . . 231

8.3.3 Summary. 233

8.4 Person Rail Trip Estimates 233

8.4.1 Final Ridership Totals 235

8.5 Demographic Factors and the System 235

8.6 Scenario for Years 2000 and 2020 236

8.7 Conclusion 237

References - Chapter 8. 239

Chapter 9: Cost Analysis 240

9.1 Introduction 240

9.1.1 Purpose and Scope 240

9.1.2 Definition of Systems 240

9.1.3 Capital Costs 241

9.1.4 Operating Costs 241

9.2 System Capital Costs Defined 243

9.2.1 General 243

9.2.2 Development Costs 243

9.2.3 Route Construction. 244

9.2.4 Right-of-Way and Land Acquisition . 244

9.2.5 Guideways 244

9.2.6 Traction Power. 245

TABLE OF CONTENTS (Continued)

Page

9.2.7 Stations. 246

9.2.8 Signal System 247

9.2.9 Communication and Surveillance Systems 247

9.2.10 Automatic Train Control 247

9.2.11 Automatic Vehicle Monitoring. . . . 247

9.2.12 Track Crossing pads 248

9.2.13 Maintenance and Storage Depots. . . 249

9.3 System Operating Costs Defined 249

9.3.1 General 249

9.3.2 Transportation Costs. 249

9.3.3 Vehicle Maintenance Costs 250

9.3.4 Permanent Way Maintenance Costs . . 250

9.3.5 Power Costs 251

9.3.6 General and Administrative Costs. . 251

9.4 Capital and Operating Costs: Modernized System 251

9.4.1 Capital Costs Projections. 251

9.4.2 Operating Costs Projections. 253

9.5 Capital and Operating Costs: Expanded System 257

9.5.1 Capital Costs Projections. 257

9.5.2 Operating Costs Projections. 260

Bibliography - Chapter 9. 263

TABLE OF CONTENTS (Continued)

Page

Chapter 10: Finance Study. 264

10.1 Introduction. 264

10.1.1 Purpose and Scope. 264

10.1.2 1983 Financial Realities 265

10.2 The economic and Politics of Transit Support 267

10.2.1 Why Finance: Financial and non-financial rationale. 267

10.2.2 The Players and Points-of-View . . . 269

10.2.3 SEPTA Funding Needs, Practices and Constraints. 270

10.3 Recent Funding Proposals and Legislation . . 271

10.3.1 State Level Proposals 271

10.3.2 State Funding: Existing Legislation. . 272

10.3.3 Regional Level 272

10.4 Financial Requirements of the Proposed System 273

10.4.1 Capital and Operating Costs 273

10.4.2 Capital Finance Parameters and Constraints 274

10.5 Proposed Capital Funding Scenarios 277

10.5.2 A Traditional Approach: Scenario No. 1 277

10.5.2 A New Suggestioon: Scenario No. 2 . . 279

10.5.3 Dedicated Revnue Sources: Scenarios No. 3a, b, c and d. 281

10.5.4 Borrowing: Scenario No. 4. 290

TABLE OF CONTENTS (Continued)

Page

10.5.5 Multiple Options: Scenario No. 5 . . 292

10.5.5.1 Lottery. 293

10.5.5.2 Property Sales 294

10.5.5.3 Equipment Trust Certificates 294

10.5.5.4 Safe Harbor Leasing. 294

10.5.5.5 Joint Development. 295

10.6 Proposed Operational Funding 295

10.7 Novel Financing Techniques 297

10.8 Summary. 298

Chapter 11: Evaluation. 300

11.1 Evaluation 300

11.1.1 Introduction. 300

11.1.2 Study Methodology 301

11.1.3 Evaluation Methods. 303

11.1.4 Evaluation Matrix 309

11.2 Recommendation 316

11.2.1 Rationale 317

11.2.2 Organizational Proposal 321

Conclusion 325

Appendix I: Technology Characteristics 334

Appendix II: Fare Collection Systems. 340

Appendix III: Scheduling 351

Appendix IV: Year 2000 Maximum Potential Ridership for individual alignments (Alt. 1) . . . 353

TABLE OF CONTENTS (Continued)

		Page
Appendix V:	First Round Total Person Trip Matrix	354
Appendix VI:	Philadelphia Region Rail Ridership .	368
Appendix VII:	Employment Profile of Affected Counties (Thousands)	369
Appendix VIII:	Population Profile of Affected Counties (Thousands)	370
Appendix IX:	1. Annual Car-miles; Modernized System, First Phase	371
Appendix IX:	2. Annual Car-miles; Modernized System, Second Phase.	372
Appendix IX:	3 Annual Car-Miles; Expanded System.	373

LIST OF FIGURES

Page

Chapter 1: The Commuter Rail System in the Phiadelphia Metropolitan Region

Figure I-1, Existing Commuter Rail Network . . . 11

Figure I-2, Reading District Lines Mileages. . . 14

Figure I-3, Reading District Lines 15

Figure I-4, Phiadelphia District Line Milages. . 18

Figure I-5, Philadelphia District Lines. 19

Figure I-6, New Airpor High Speed Line 23

Figure I-7, Center City Commuter Connection . . . 26

Figure I-8, Commuter Rail Station 28

Figure I-9, Commuter Rail Stations by Line and Systemwide. 30

Figure I-10 Track Ownership and Mileage 33

Figure I-11 Track Ownership 34

Figure I-12 Physical Characteristics of Track by Lines. 35-36

Figure I-13 Commuter Railroading Stock. 42

Figure I-14 Average Weekday Ridership by Line . . 46

Figure I-15 Commuter Rail System Operating Costs, Revenues, Deficits and Subsidies (Selected Years 1971-1981) . . 50

Figure I-16 Commuter Rail Service Operating Subsidy Requirement by Source (1971-1981) 53

Figure I-17 Commuter Rail Projects Funded Prior to FY 1983. 56-57

LIST OF FIGURES (Continued)

Page

Chapter 2: Land Use

Figure 2.1 General Implications of Development Scenarios. 70

Figure 2.2 Land Use-Transportation Possibilities for the Delaware Valley Region 73

Figure 2.3 System of Multipurpose Centers 82

Figure 2.4 Multipurpose Centers 88

Figure 2.5 Proto-typical Multipurpose Center. . . 90

Chapter 3: Alignment and Technology of Alternative 1 and Alternative 2

Figure 3.1 Present System Ridership by Line. . . 99

Figure 3.2 Alternative One: Modernized Systems . 102

Figure 3.3 Media-Granite Run Mall-Lenni and Chester-West-Chester Alignments . . . 106

Figure 3.4 Lenni Station: Proposed Layout . . . 108

Figure 3.5 Frazer-King of Prussia-Norristown Alignment 109

Figure 3.6 Holmsburg-Neshaminy-Oxford Valley Mall Alignment. 113

Figure 3.7 Alternative to: Expanded System. . . 115

Figure 3.8 Passengers Buying Tickets 122

Figure 3.9 Ticket, Transfer and Turnstile. . . . 126

Figure 3.10 Car Plans. 130

Figure 3.11 Car Interior 132

LIST OF FIGURES (Continued)

Page

Chapter 4: Stations

Figure 4.1 Stations Considered for Elimination: Modernization and Expanded System . . 144

Figure 4.2 Existing Stations Requiring High-level Platforms. 146

Figure 4.3 Parking Space Projections: Modernized and Expanded Systems. 147

Figure 4.4 Parking Space Alignments. 139

Figure 4.5 Existing Stations Considered for Major Improvements. 151

Figure 4.6 Lansdale-Doylestown, Warminster and Fox Chase Lines 152

Figure 4.7 Media and Wilmington Lines. 153

Figure 4.8 Norristown and Paoli Lines. 154

Figure 4.9 Trenton and Chestnut Hill West Lines . 155

Figure 4.10 Circumferential and Northeast Philadelphia Lines. 156

Figure 4.11 Potential New Station Location. . . . 158

Figure 4.12 Recommended Locations for New Stations and Joint Development 159

Figure 4.13 Commuter Type High-density Development Station 165

Figure 4.14 Proto-type Low Density Development Station 166

Figure 4.15 Prototype Employment Development Station 168

Figure 4.16 Prototype Park and Ride Station . . . 169

Chapter 6: Operations

Figure 6.1 Operating Speed Improvements 202

LIST OF FIGURES (Continued)

Page

Figure 6.2 Recommended Track Layout at North Philadelphia. 203

Figure 6.3 Line Pat Rings and Vehicle Requirements. 204-205

Chapter 7: Fare Structure

Figure 7.1 Existing Zone Fares 213

Figure 7.2 Proposed Fare Structure 219

Figure 7.3 Current System Ridership and Revenue 224

Figure 7.4 Operating Costs, Modernized and Expanded System 225

Chapter 8: Ridership

Figure 8.1 Populaation Profile of the Study Area 228

Figure 8.2 Employment Profile of the Study Area 228

Figure 8.3 Population and Employment Shares in Affected Counties . . . .

Chapter 9 Cost Analysis

Figure 9.1 Capital Cost Estimates: Modernized System. 252

Figure 9.2 Annual Operating Costs: Modernized System (1st Phase). . . . 255

Figure 9.3 Annual Operating Costs: Modernized System (2nd Phase). . . . 258

Figure 9.4 Capital Cost Estimates: Expanded System. 259

Figure 9.5 Annual Operating Costs: Expanded System. 262

LIST OF FIGURES (Continued)

Page

Chapter 11 : Evaluation

Figure 11.1 Evaluation Matrix. 310

Figure 11.2 Urban Transporation, Actors and Issues. 311

INTRODUCTION

by The Entire Study Group

From Philadelphia's plush western and northwestern suburbs to the old industrial cores of Conshohocken, Norristown and Manayunk, the region's railroads helped to shape many of the development patterns which still remain. Despite the changes which have occurred in the decades since its beginnings in the 1830's, the Philadelphia area continues to enjoy a remarkable network of commuter rail lines.

But while the lines were once the proudest assets of both the Pennsylvania and Reading railroads, they now operate in continual crisis under their newest caretaker, the Southeastern Pennsylvania Transportation Authority (SEPTA). This preservation of historic railroad lines is remarkable, but so is the fact that similarly antiquated work rules, management practices and equipment have survived as well. Similar to the transit dilemma in other parts of the country, Philadelphia's extensive commuter rail network faces keen challenges from the use of the automobile. But more important than the competition which occurs every morning for rush hour riders are the region's overall growth patterns of the last forty years.

When the railroads were first built into the suburbs, they provided the only link for businesses and people with the region's heart, Philadelphia proper. Both households and businesses locating further out depended on access to the railroad lines. The universal marketing of the automobile and the construction of new highways provided initially, an independent mode of travel to and from the city, and later, the possibility of locating quite independently of the central city.

Not surprisingly, the radial alignments to downtown which the railroads had operated for decades were no match for either the convenience of the automobile nor the increasing demand for travel to destinations other than Center City. Moreover, the railroads continued to operate under work rules that only made sense when labor was cheap and there was no competing means of travel. Rolling stock was dilapidated; stations, track, catanary and other fixed facilities were all in disrepair.

In what proved to be the first step in an eventual public takeover, capital assistance was provided by a public agency to purchase new rail cars. This was followed by additional capital expenditures and eventually operating assistance to cover growing deficits. Local governments, reluctant to pay the full share of the overwhelming shortfalls, imposed a series of fare increases and service cutbacks. As service was cut, ridership and revenues would fall, plunging the system into a vicious spiral of fare hikes, falling ridership, mounting deficits and further service cutbacks. The system now operates in this downward-moving vortex which threatens to swallow the entire system, including its latest monumental investment, the Center City Commuter Connection.

While parts of the system are relatively new and in good repair, others have endured years of deferred maintenance. Taken as a whole, the system is outmoded. It is no longer enough to perform patch-up work on the system. Bold new steps must be taken to make the system manageable and affordable. The price tag, frankly, is high, but the team questions whether the region can afford not to do something serious of the sort. If the commuter rail system is an asset, then it must be protected and nurtured. It is pointless to pretend that the system is not now moving towards death with dignity.

This study deals with the feasibility and desirability of transforming the Philadelphia area's commuter rail lines into a modern regional rail system. The study considers two alternatives which can be implemented over the coming decades and assesses the costs and benefits to the region of each alternative and extrapolates a trend line to present what will occur if nothing is done.

The first alternative, the Modernized System, presents a phased-in process for modernizing the existing system.

One new line is added, but as a whole, this alternative modernizes the system's best-performing lines, retaining and improving service on those lines which perform well and eliminating service on those lines which seem to lack any prospect for improved ridership in the future.

On the other hand, the second alternative, the Expanded System, represents the major innovation in the team's work. It is based on consideration of land use issues and promotion of regional centers and sub-centers as growth nodes. The rail network is then applied to this scheme in order to enhance each center's accessibility and joint development prospects, as well as the overall health of the rail network. Even viewed in the most optimistic light, it is unlikely to be an overnight success. It will require some patience on the part of the region and some re-thinking on the part of developers before this plan begins to have a real impact on future development and transportation in the region.

This report first provides an overview of the history of the system, followed by a detailed account of how it now operates and its inherent problems. The study next considers the land use implications of rail development in the region. An analysis of old and new lines and alignments is undertaken next, and an applicable technological package is suggested. Station location and joint development prospects are examined in detail. This is followed by a discussion of operational concerns and the fare structure to be used.

Ridership estimates are provided and explained along with some of the assumptions made in forecasting the region's future demographic characteristics. Capital and operating costs are analyzed and a number of financial scenarios are presented. Finally, the report concludes with a systematic evaluation of the advantages and disadvantages of both systems, along with their implications for various regional actors. Based on this, the study team recommends a preferred alternative.

The study team consisted of John Allen, Joe Augustyn, Carmen Blassini, Peter Bromley, Scott Gibbons, Mehdi Hitewesh, Jaime Martinez and Aurelio Menendez, all candidates for the degree of Master's of City Planning from the University of Pennsylvania. This report has been prepared in partial fulfillment of the Department of City and Regional Planning's degree requirements.

Apart from the work that went into each student's individual sections and chapters in this report, most also participated in research, task meetings and group memoranda, which, while vital to the conduct of the study, is not specifically acknowledged in the report's various sections. Each team member participated in the following tasks:

John Allen: Editor, technology, land use, alignments, schedules, inventory, capital costs

Joe Augustyn: Capital costs, joint development, financial scenarios

Carmen Blassini: Technology, stations, land use, capital costs

Peter Bromley: Group Coordinator, operations, schedules, alignments, technology, inventory, land use, ridership (Alternative II), capital costs

Scott Gibbons: Population and ridership, land use

Mehdi Hitewesh: Evaluation, population and ridership

Jaime Martinez: Comptroller, history, inventory, operations, alignments, ridership (Alternative II)

Aurelio Menendez: Alignments, schedules, operating costs, fares, station locations, ridership (Alternative II)

All team members participated in the evaluation process.

CHAPTER 1

THE COMMUTER RAIL SYSTEM IN THE PHILADELPHIA METROPOLITAN REGION

by

Jaime Martinez

1.1 Introduction

The present commuter rail system in the Philadelphia metropolitan region has evolved over a period of approximately 150 years. Over this period, the system has experienced major changes in the technology used, size, operation, management and the role it plays in shaping regional growth and development. This chapter presents a general overview of the commuter rail system as it exists today, its history and current problems.

The chapter is divided into three sections. The first section presents a synopsis of the development of commuter rail in the region, with emphasis on network, technology, management and operations. The second section describes the present commuter rail system infrastructure and rolling stock. The fixed infrastructure components described include track, signal and electrical system, stations and parking, maintenance facilities and others. The third and final section examines the services provided, cost, financing and management of the system. This section concludes with a brief assessment of the long-term problems confronting the region with regard to the continued operation of the commuter rail system.

1.2 Development of Commuter Rail in the Region

The origins of commuter rail service in the Philadelphia metropolitan region date back to the 1830's when railroads began to operate passenger service on the state-built railroad to the west, the "Main Line of Public Works."[1] This line, opened in 1834, was a combination of canals, inclined plane railways, and horse-drawn railways connecting Philadelphia and Pittsburgh. In the same year, fueled by the movement of population from downtown Philadelphia to suburban areas, the Philadelphia and Germantown Railway opened for passenger service and in 1835 an extension of this line was built to Norristown. By the 1850's, service between Center City Philadelphia and such outlying communities as Chestnut Hill, Norristown and the Germantown area was quite extensive, with peak hour service as frequent as four trains in each direction.

The Pennsylvania and Reading Railroads dominated the development of passenger service in the region during the second half of the nineteenth century.[2] The Reading Railroad was formally opened in 1842, though portions of the system were operated as early as 1839. Passenger service on the main line between Philadelphia and Reading, for example, began in 1839. The Reading Railroad expanded significantly in 1870 when it leased and later acquired the Philadelphia, Germantown and Norristown Railroad and the Chestnut Hill Railroad which connected downtown Philadelphia with Germantown and Norristown and Chestnut Hill respectively. The Reading's service area was further expanded in 1879 with the leases of the North Pennsylvania Rail Line to Bethlehem, the Northeast Pennsylvania Railroad to Hatboro and the Philadelphia, Newtown and New York Railroad to Newtown in Bucks County. By the 1880's, the Reading Company was firmly established in the northeast and northwest of the Philadelphia region and controlled all of what remains in use today as part of the Reading District network.[3]

The Pennsylvania Railroad started rail operations in the 1850's when the company gained trackage rights to the state-financed Philadelphia and Columbia Railroad Line. This trackage later became the Pennsylvania Railroad's main line to the west. By 1880, the Pennsylvania Railroad had established itself as one of the largest commuter rail operations in the region. It had obtained control of the Philadelphia, Wilmington and Baltimore railroad routes to the south and the United New Jersey Railroad and Canal Company Lines to the northeast. The Pennsylvania Railroad further enhanced its position through the establishment of the Philadelphia, Germantown and Chestnut Hill Railroad in 1884 to compete directly with the Reading Company in the

Germantown and Chestnut Hill areas. By the 1890's, the Pennsylvania Railroad controlled the trackage over the six commuter railroad lines that now form the Philadelphia District.

The growth and expansion of the commuter rail system during the nineteenth century was an important influence on the development of the Philadelphia area. Many of the early settlements and towns in the region emerged as a result of the established railroads. New developments outside the built-up areas were closely tied to the availability of rail service and located near railroad stations. In some cases, privately-owned stations were built to maximize personal convenience and to facilitate passenger access between the outlying areas and Center City. Commuter rail stations became magnets of growth, and new suburban communities clustered around the stations. As a result, many small to medium-size communities, such as those encountered along the Philadelphia-Harrisburg main line and the Reading's Bethlehem Branch sprang up--the nineteenth century commuter railroad's mark on the regional landscape.

From the 1900's to the present, the commuter rail network in the Philadelphia region remained relatively static. Little new track was laid and few rail miles were abandoned. During this period, however, a number of improvements were undertaken to modernize the system.

Between the 1900's and the 1940's two major system improvements were pursued. The first involved the systematic elimination of grade crossings to reduce the problems created by increased highway traffic. When the system was originally designed, highway traffic was low and with few exceptions, tracks were laid at-grade and without grade separation. Grade crossings became major safety hazards, as highway traffic grew. At the same time, the commuter trains themselves were becoming larger and faster. As a result, during the period before and after World War I the Reading and Pennsylvania railroads made substantial efforts to eliminate grade crossings by building tunnels, bridges, embankments and other grade separations.[4]

The 1910's also saw the beginning of suburban passenger service electrification in the region. Encouraged by the growth in passenger demand and spurred on by the need to curtail cost and speed up service, the Pennsylvania began its 11,000 volt A.C. electrification in 1913 with the main line to Paoli and the Chestnut Hill West Branch. These two lines were electrified by 1915 and 1918 respectively. By 1930, catenary wires had been installed on the New York-Washington line between Trenton and Wilmington, and on the West Chester Branch to Media and the Norristown Branch.[5] The Reading Railroad did not begin to electrify its lines until the late 1920's. By 1933, however, the electrification of the Reading District covered 84 route-miles of suburban track--including the lines to West Trenton, Hatboro, Doylestown, Chestnut Hill East and Norristown.[6] On the longer, and less traveled Reading lines such as north of Lansdale on the Bethlehem Branch and northwest of Norristown on the Pottsville Branch, steam operations continued. By the end of the 1930's virtually all commuter rail had been electrified.

Unlike many other cities in the United States, Philadelphia's commuter rail system escaped the massive system abandonments and service cutbacks which hit other cities with commuter rail systems immediately after World War II. While Philadelphia's commuter railroads did lose some ridership during this period, the level of decline was not significant enough to warrant massive train discontinuances. Instead, the railroads opted for gradual reductions in service frequencies and the elimination of only the most marginal lines. Overall, the electrified system of the 1930's remained relatively unchanged through the mid-1940's.

The preservation of the rail network during the 1940's, however, was not an accurate indicator of the economic viability of the system. After World War II, the commuter railroads began to experience major signs of financial distress due to continued losses in ridership and escalation in operating costs. Like many other cities in the country, the commuter rail ridership losses in the Philadelphia region were partly due to changes in the regional distribution of population and employment and the availability of the automobile for transportation. In response to the reduced profitability of commuter operations, the railroads curtailed services, increased fares and minimized capital expenditures on system maintenance and improvements. All of these measures only led to further reductions in ridership and severe deterioration of the system's physical plant and rolling stock.

By the late 1950's, it became clear that there were three possible alternatives for dealing with the railroads' financial problems: (1) abandon all passenger service; (2) convert parts of the system to rail transit; and (3) continue operations under a program of public subsidies.

In 1958, the City of Philadelphia decided to undertake a six month pilot subsidy program on the Chestnut Hill East and West Branches of the Reading and Pennsylvania railroads respectively. Under this program, the City appropriated $160,000 for subsidies to the railroads in exchange for agreed-upon service increases and fare reductions, among other improvements. The subsidy program was quite successful in generating new ridership, and by the end of the six-month period, the pilot program was extended to one year, after which the two lines showed a 21.8 percent increase in ridership. The program was again extended and in 1960, the City created the Passenger Service Improvement Corporation

(PSIC), a minicipal agency in charge of the administration of the subsidy program for most of the commuter rail lines serving the City.

In 1961, encouraged by the relative success of the city-sponsored subsidy experiments, the three suburban counties of Bucks, Montgomery and Chester plus the City of Philadelphia created the Southeastern Pennsylvania Transportation Compact (SEPACT) to administer an experimental subsidy program for three commuter rail lines: the Pennsylvania Railroad's Levittown line to the northeastern suburbs, and the Reading's Hatboro and Lansdale lines to the northwest suburbs.[7] The SEPACT subsidy program marked the first time that the federal government participated in the funding of a commuter rail subsidy program. Two-thirds of the $3.1 million total program was funded by the Federal Housing Authority.

Recognizing the need for a systemwide, regional approach to the transportation problems of the metropolitan area, the state legislature established the Southeastern Pennsulvania Transportation Authority (SEPTA) in 1963. As an instrument of the state, SEPTA was authorized to preserve, improve and expand the regional transportation system in the City of Philadelphia and the four suburban counties (Bucks, Chester, Delaware and Montgomery). By 1965, SEPTA began to manage the programs that its predecessor SEPACT had initiated.

In 1968 the Pennsylvania Railroad merged with the New York Central to create the Penn Central Railroad. During the early 1970's, financial problems led to the bankruptcy of the Penn Central, the Reading and other major eastern railroads.

In 1976, the U.S. Congress set up the Consolidated Rail Corporation (Conrail) under the Railroad Revitalization and Regulatory Reform Act of 1976 (4-R Act) to operate passenger and freight services previously provided by the bankrupt railroads. Conrail began operations in the Philadelphia region in 1976 under a purchase of service agreement with SEPTA. Under the agreement, SEPTA established fares and the frequency and levels of service to be provided while Conrail actually operated the service, providing train crews, station agents, on-board supervision, maintenance of equipment and in certain areas right-of-way maintenance. While Conrail's takeover of the Reading and Penn Central Railroads placed the commuter rail operation under a single management, the two systems remained operated as separate entities.

The Conrail operation of commuter rail services in the region lasted for approximately five years (1976-1982). The termination of Conrail passenger service operations came as a result of the enactment of the Northeast Rail Services Act by Congress in 1981, which mandated that Conrail cease operations of commuter service by December 31, 1982. Beginning on January 1, 1983, SEPTA took over operation of the commuter rail service in the region.

1.3 The Existing Commuter Rail System

1.3.1 General Overview of the System

The existing commuter rail system consists of twelve operating rail lines connecting the outlying suburban counties of Bucks, Chester, Delaware, Montgomery and adjacent portions of the states of Delaware and New Jersey with downtown Philadelphia. As currently operated by SEPTA, commuter services are operated under the Reading Division which operates on six lines previously owned and operated by the Reading Railroad, and the Philadelphia District which consists of six lines from the Pennsylvania and later the Penn Central Railroad. The physical network on the Reading and Philadelphia districts are generally compatible with each other but they are currently operated as separate systems. (See Fig. I-1) The Reading District lines radiate from the Reading Terminal, a stub-end elevated terminal located on Market Street between 11th and 12th Streets in Center City. From Reading Terminal a four track trunk line runs north to 16th Street Junction where the first of the six lines branches off to Norristown. The four track main line continues north to Wayne Junction, where the Chestnut Hill East branch departs from the main line and runs to Chestnut Hill

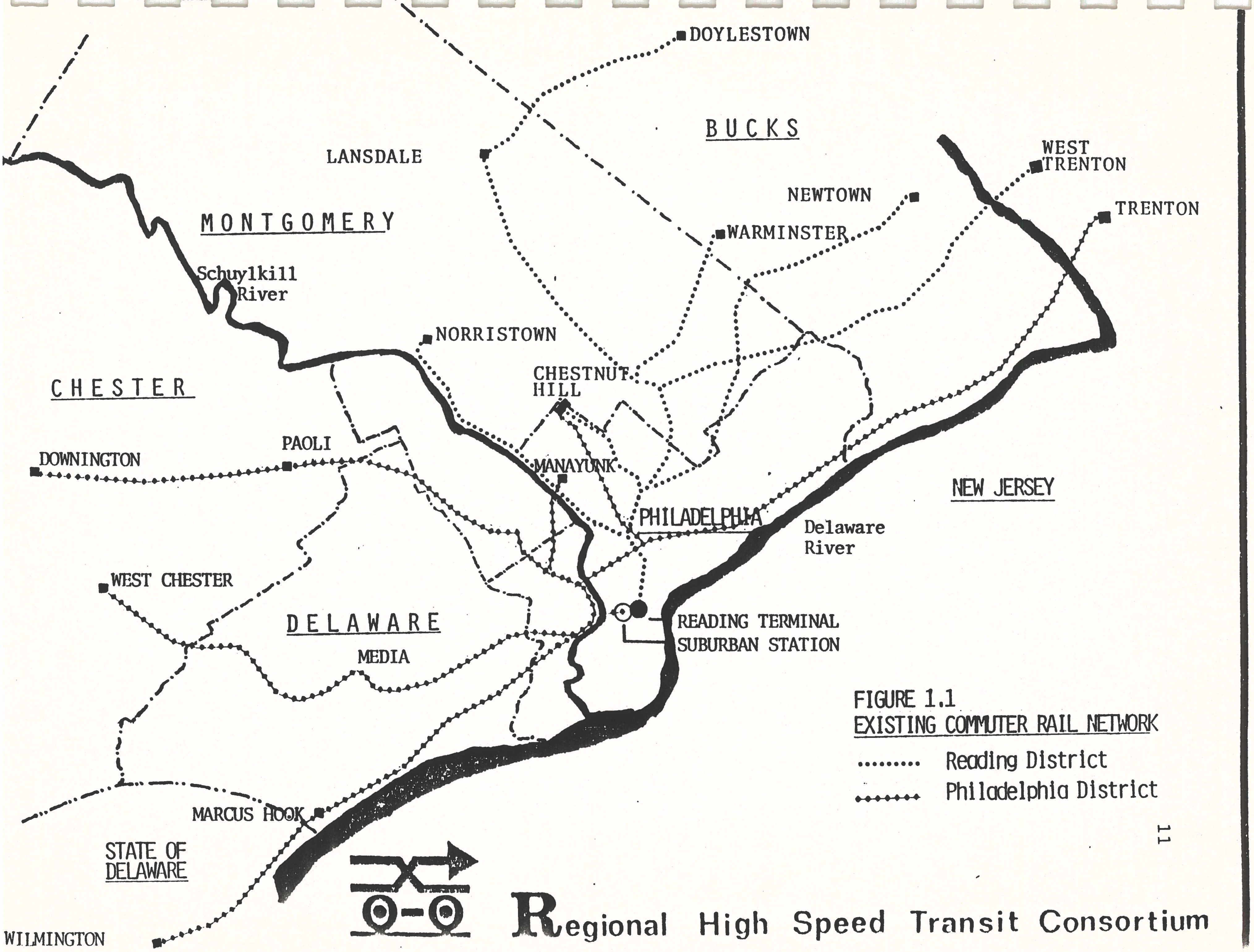


FIGURE 1.1
EXISTING COMMUTER RAIL NETWORK

East. North of Wayne Junction, there are only two tracks, and there are three more junctions where each of the remaining branches diverges from the trunk line. These points are Newtown Junction for the branch to Fox Chase/Newtown; Jenkintown for the West Trenton Branch to Trenton; and Glenside for the Warminster Branch to Warminster. From Glenside the Bethlehem Branch continues northwest to Lansdale, where a branch goes on to Doylestown.

Unlike the Reading lines, the lines on the Philadelphia District go their different ways close to the terminal. Beginning at the existing stub-end underground terminal at Penn Center, the Philadelphia District lines go to the upper level of 30th Street in West Philadelphia where the Wilmington line and the West Chester branch turn south to the junction at Arsenal. The other four lines, Chestnut Hill West, Manayunk, Paoli and Trenton, continue northwest on the suburban line to Zoo Junction, where the Paoli and Manayunk lines go west to Valley and the Chestnut Hill West and Trenton lines go to North Philadelphia. At Arsenal, Valley and North Philadelphia, each line diverges to go its own separate way.

The next sections describe in further detail the twelve operating lines that make up the commuter rail system, the Airport High Speed Line (AHSL) which is presently under construction and will begin operations by 1985 and other system facilities including terminals, stations and parking, signal systems, electric traction power and rolling stock.

1.3.2 Detailed Description of the System

1.3.2.1 The Reading District Lines.

The six Reading District lines connect downtown Philadelphia with outlying communities in Montgomery and Bucks Counties and the state of New Jersey. Figure 1-2 shows the total and unduplicated mileages for the six lines. Total Length Miles as shown for each line is the track distance between the Center City terminal and the end point of each line. The unduplicated mileage consists of total Length Miles per Line adjusted downward to avoid double-counting track sections used by more than one Line. Figure 1-3 shows the Reading District network.

--Chestnut Hill East Line. The Chestnut Hill East line branches off from the Reading main line at Wayne Junction and runs for some 5.8 miles to Chestnut Hill. It is a double track line with no grade crossings. Currently Contrail operates subsidized freight service under contract with the Pennsylvania Department of Transportation on a section of this line between Wayne Junction and Germantown. Historically, this branch has competed with the former Pennsylvania Railroad's Chestnut Hill West Branch which is longer and the better patronized of the two.

Figure 1-2

Reading District Line Mileages

Line	Total Length Miles	Total Unduplicated Miles
Chestnut Hill East	10.8	5.8
Fox Chase*	11.1	5.4
Lansdale/Doylestown	34.4	34.4
Norristown	18.0	14.7
Warminster	20.6	8.3
West Trenton	32.5	24.5
Total	127.4	93.1

*Excludes the non-electrified 15.2 mile section between Fox Chase and Newtown.

Sources: Orth-Rodgers and Associates, Inc., Commuter Rail Contingency Plans: Alternative Mobility Options for the Delaware Valley, Final Report, December 1981, p. 6.

Consolidated Rail Corporation (Conrail), "SEPTA Commuter Region Line Diagrams," 1982, pp. 1-25.

--Fox Chase-Newtown Line. The Fox Chase-Newtown line was one of the few Reading lines in the area not electrified during the 1930's. In 1966, however, the catenary was extended from Wayne Junction to Fox Chase. The 15.2 mile section of this line between Fox Chase and Newtown is not electrified, and service is provided by Rail Diesel Cars (RDCs). The Fox Chase line leaves the Reading main line at Newtown Junction and takes a double track electrified line from Newtown Juncton to Cheltenham Junction. At Cheltenham Junction the line becomes single track. The electrification ends at

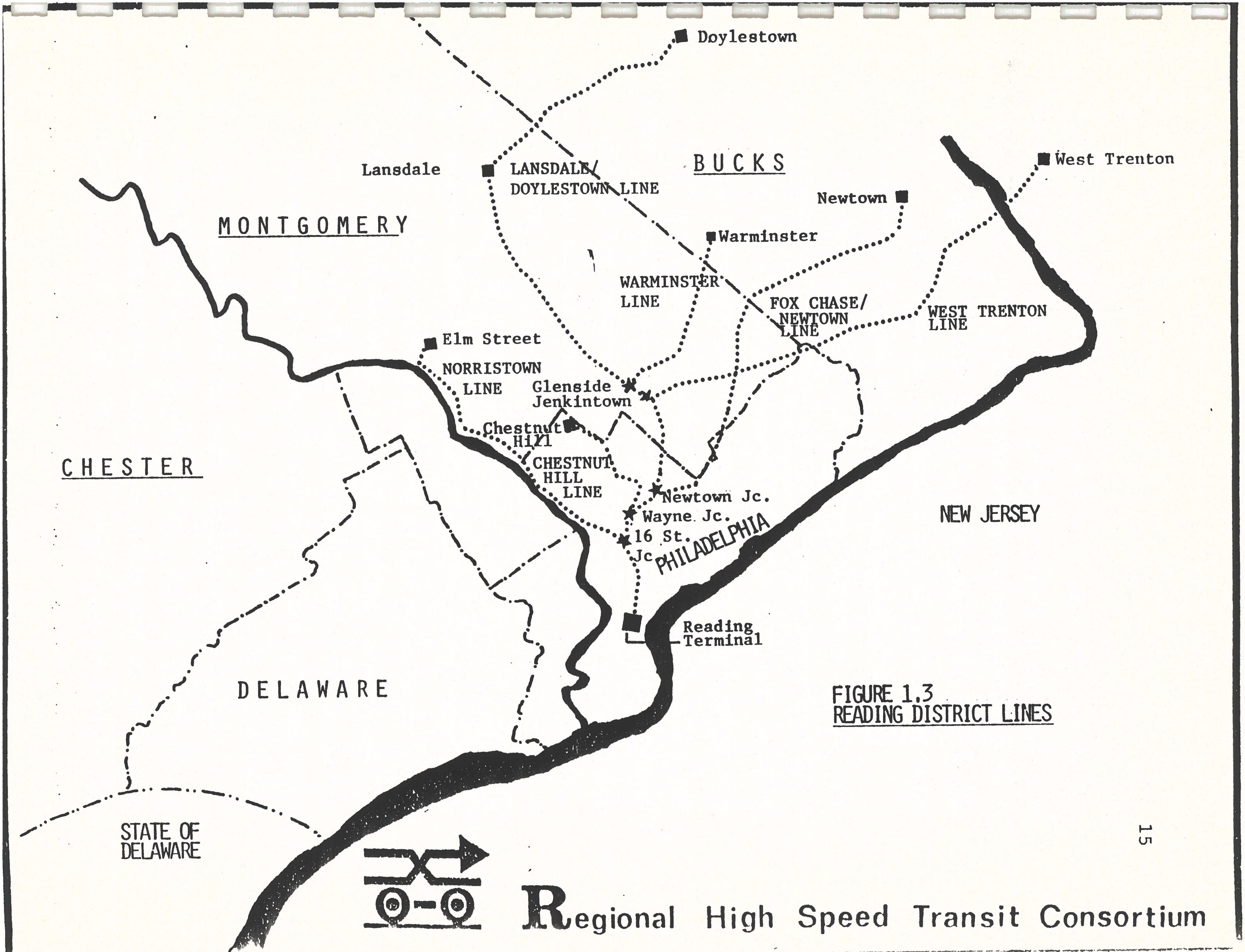


FIGURE 1.3
READING DISTRICT LINES

Fox Chase. The line continues from Fox Chase to Newtown for some 15.2 miles through areas of Montgomery County where population densities are low and there are only a few stations, and Bucks County where the line goes through the growing areas of Southampton and Churchville up to Newtown.

--Lansdale/Doylestown Line. The Lansdale section of this line is a continuation of the old Reading Railroad trunk line connecting downtown Philadelphia with Lansdale. North of Glenside, the Lansdale branch goes through Oreland, Fort Washington, Ambler, and North Wales in Montgomery County. Up to 1981 the line diverged at Lansdale with a branch continuing north to Quakertown and another to Doylestown. Today only the Lansdale-Doylestown section is still used for passenger service. The section between Glenside and Lansdale is a two-track electrified line. From Lansdale to Doylestown the line is electrified but only single track. There are two electrified sidings along this 10.0 mile section to allow inbound and outbound trains to pass each other between Lansdale and Doylestown. South of Glenside the Lansdale/Doylestown trains travel on the Reading trunk line through Jenkintown, Wayne Junction and 16th Street Junction to reach Reading Terminal in Center City.

--The Norristown Line. Like all other Reading District lines, the Norristown line originates at Reading Terminal from where it goes north on the four track segment shared by all Reading District lines. At 16th Street Junction, 3.3

miles north of the terminal, the Norristown line branches off to the northwest and runs for 14.7 miles to DeKalb Street in Norristown over the double tracked old main line to Reading (which is electrified to DeKalb Street). Between DeKalb Street and the Elm Street Terminal there is a single track, electrified branch less than a mile long. Presently Conrail operates some freight service between Norristown and 16th Street Junction.

--West Trenton Line. This line branches off from the Reading main line at Jenkintown and travels northeast for 24.5 miles to West Trenton on the Reading's main line to New York. The West Trenton line is electrified throughout. It is double-tracked except for the section between Neshaminy Falls and Woodbourne, which is triple-tracked. This branch also handles some freight traffic between Jenkintown and Neshaminy Falls. In 1982 SEPTA discontinued service beyond Yardley due to low patronage on that section.

--Warminster Line. This line, linking downtown Philadelphia with Warminster in Bucks County, consists of the old Hatboro line plus a two-mile extention to Warminster which was electrified in 1964. The Warminster branch leaves the Reading's main trunk west of Glenside where it starts as an electrified double track and continues northeast to Roslyn. Between Roslyn and Warminster, a distance of 6.3 miles, the line runs on a single track. To allow trains to run back and forth at existing frequencies, there are electrified sidings north of Willow Grove and at Hatboro. Conrail currently runs freight trains between Glenside and Bonair.

1.3.2.2 Philadelphia District Lines. The six lines of the former Penn Central radiate from the terminal at Suburban station to the north, northeast, northwest and southwest of the Philadelphia metropolitan region. Figure 1-4 shows the line-miles and unduplicated mileages for the six lines on the Philadelphia District. Figure 1-5 shows this district's six lines.

Figure 1-4

Philadelphia District Line Mileages

Line	Total Length Miles	Total Unduplicated Miles
Wilmington	26.7	26.7
Media/West Chester	27.5	25.4
Chestnut Hill West	12.0	11.1
Trenton	32.4	27.0
Paoli/Downington	32.3	29.9
Manayunk	8.2	4.2
Total	139.1	124.3

Source: Commuter Rail Contingency Plans: Alternative Mobility Options for the Delaware Valley, op. cit., p. 7

"SEPTA Commuter Region Line Diagrams," op. cit, pp. 1-25.

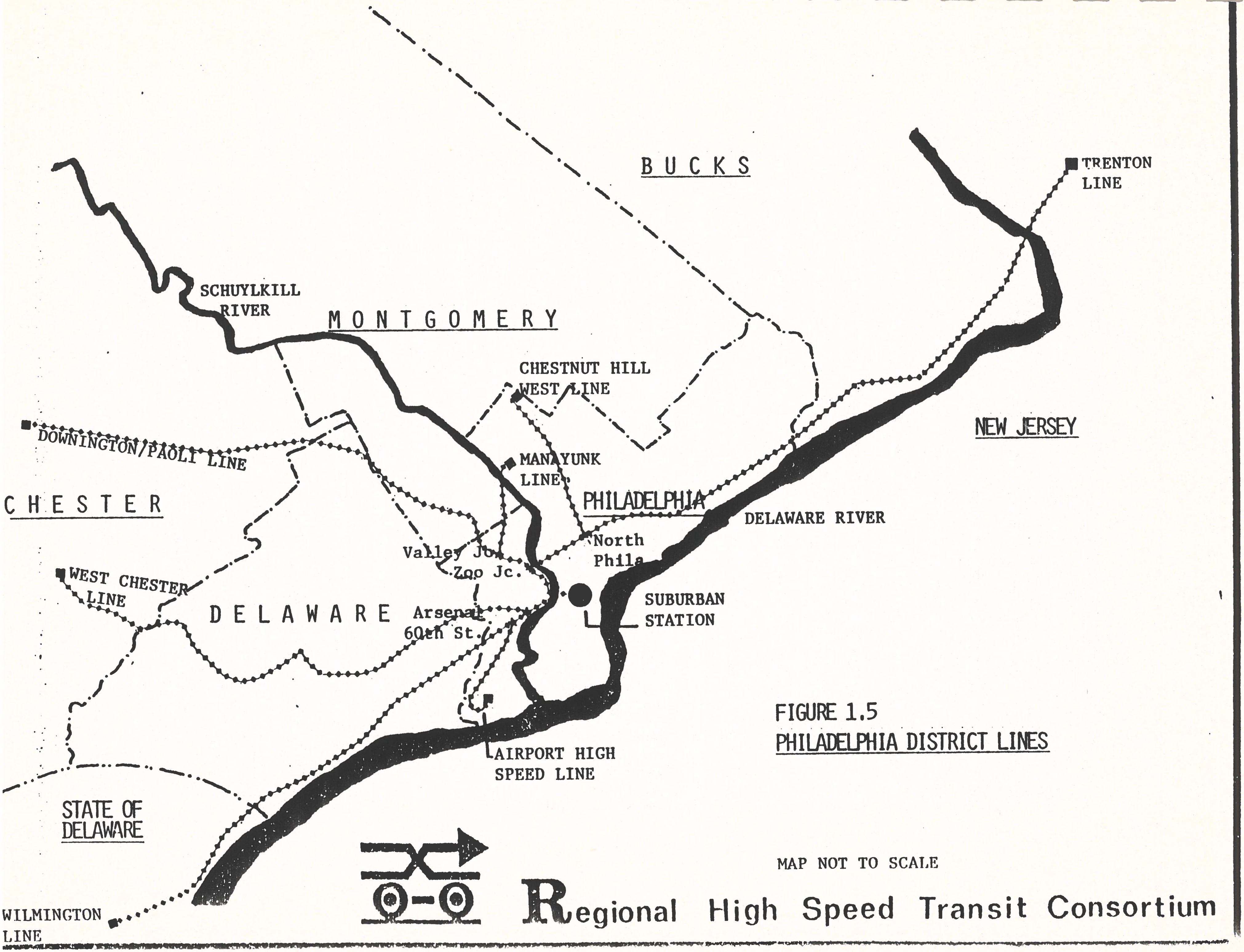


FIGURE 1.5
PHILADELPHIA DISTRICT LINES

--The Wilmington Line. This line begins at Suburban Station and runs west to 30th Street Station, where it turns southwest to Arsenal. Here the suburban trains join Amtrak's Northeast Corridor main line to Washington. It is 17.1 miles from Center City to Marcus Hook near the Delaware border and another 9.6 miles from there to Wilmington, Delaware. Amtrak's Washington main line consists of four electrified, grade-separated tracks from Arsenal to Marcus Hook. The commuter trains and Amtrak's intercity trains generally use the outside rails while the inside tracks are normally for freight trains. This line serves southwestern Delaware County, including the City of Chester, and also the industrial corridor between Chester and Wilmington.

--Media/West Chester Line. This line extends from Suburban Station and shares the Wilmington line tracks to Arsenal. Here the Media/West Chester line branches off and goes west to West Chester. This line is double tracked between Arsenal and Media. At Media, the line switches to a single track and continues beyond Media through low-density areas in Delaware and Chester Counties until it reaches West Chester. There is a long siding at Elwyn and intermittent sidings further out on the line. Presently Conrail operates freight trains between Arsenal and West Chester.

--Paoli/Downington Line. The Paoli/Downingtown line extends from Suburban Station through 30th Street and Zoo Junction to Paoli via Amtrak's Harrisburg main line. Between

Zoo Junction and Overbrook, there are three passenger tracks used by Amtrak trains to and from the west, the Paoli local service and the Manayunk line between Zoo Junction and 52nd Street. On the section between Overbrook and Paoli, there are four electrified tracks used by both freight and passenger train operations. The line is entirely grade-separated as far as Paoli. West of Paoli, the line uses three and four track sections.

--The Manayunk Line. The Manayunk line is an 8.2 mile electrified remnant of the Pennsylvania Railroad's old Schuylkill Branch. This line uses the same alignment as the Paoli line up to the Valley interlocking west of 52nd Street. Here the Manayunk line leaves the main line to Harrisburg and goes north to Manayunk. This line was formerly double-tracked but along most of the way the former outbound track has been removed. In 1980 service was extended on a newly-electrified single-track section to Ivy Ridge. There is some freight traffic between 52nd Street and Ivy Ridge.

--Chestnut Hill West Line. This line extends from Suburban Station through 30th Street Station and Zoo Junction to North Philadelphia, where it branches off from the Amtrak main line to New York and then continues to Chestnut Hill for a branch line distance of 6.6 miles. This line is electrified and double-tracked. Freight trains currently operate on the section between North Philadelphia and Queen Lane.

--The Trenton Line. The Trenton line runs from Suburban Station to North Philadelphia where it runs northeast on the Amtrak main line to New York, a four-track, electrified, fully grade-separated line. This line connects downtown Philadelphia with Trenton, New Jersey and intermediate points such as Torresdale and Holmesburg Junction. Freight trains along with intercity and commuter passenger service operate on the New York main line between the Zoo Junction and Trenton.

1.3.2.3 The Airport High Speed Line (AHSL). The Airport High Speed Line is the first major expansion of the commuter rail network in fifty years. This new facility combines new track construction with rehabilitation of existing track facilities. It is 9.4 miles long and will directly connect downtown Philadelphia with the Philadelphia International Airport. (See Map 1-6) The line has been under construction since the mid-1970's and is expected to be in service by 1985.

The initial 2.5 miles of the Airport High Speed Line use the Penn Central tracks from Suburban Station through 30th Street Station and a section of the Wilmington and Paoli/West Chester Branch. Beyond University Avenue in West Philadelphia, the line will use renovated and newly-built tracks on the old Penn Central and Reading rights-of-way, and ultimately connect downtown Philadelphia with a major

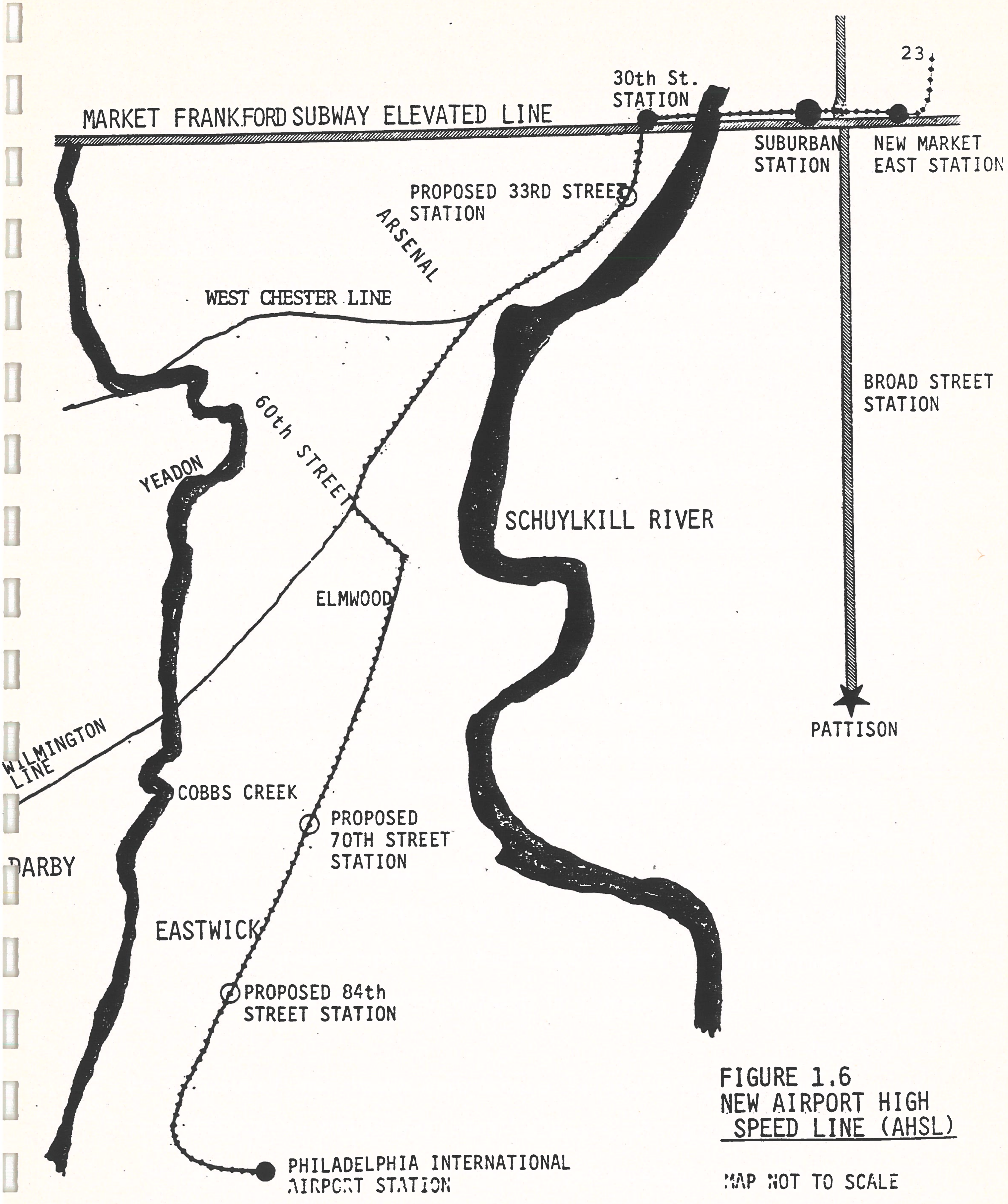


FIGURE 1.6
NEW AIRPORT HIGH
SPEED LINE (AHSL)

MAP NOT TO SCALE

passenger station at the airport terminal. Once the line is in service, one or two more stations in the Eastwick area and another station to be shared with the Wilmington and West Chester lines at 33rd Street to serve the Civic Center in the University City Area in West Philadelphia are planned to be added. It is anticipated that the Airport High Speed Line will provide a fast and reliable service between the airport and other important points in the region.

1.3.3 Terminals

Presently the Reading and Philadelphia District networks have stub-end terminals. The Philadelphia District currently terminates at Suburban Station, built in the 1930's for the exclusive use of suburban commuter trains. The terminal was built with high level platforms to expedite the loading and unloading of passengers at the terminal. At present, eight station tracks are served by four high level platforms. The tracks are located two levels below the surface. The terminal facility is linked with the Broad Street subway, the Market-Frankford subway-elevated, and the subway/surface light rail lines through a complex underground concourse system.

The Reading District operations start and terminate at Reading Terminal, an elevated facility built originally in the 1890's and modernized during the 1940's. The terminal has thirteen tracks (one of which is not electrified) which are served by seven low-level platforms. The terminal building is linked to the Market-Frankford subway-elevated line and is close to other rapid transit facilities. Once the Center City Commuter Connection (CCCC) is completed, the new underground Market East station at 11th and Filbert Streets will replace the existing Reading Terminal.

1.3.4 The Center City Commuter Connection (CCCC)

In 1984 the Center City Commuter Connection will be put into operation. This facility, the single greatest capital investment on the commuter rail system in the last fifty years, will enable continuous train operation between the Reading and Philadelphia district networks. The CCCC will link the two districts via a 1.8 mile four-track tunnel which begins at Philadelphia Suburban Station (16th Street and JFK Boulevard) and proceeds through a newly-built Market East station at 11th and Filbert Streets (see Figure 1-7). At 10th Street, the tunnel will curve to the north, running mid-block between 8th and 9th Streets to a portal at Green Street. The tracks will then climb onto a viaduct connecting with the existing Reading main line at 9th and Poplar Streets.

The commuter tunnel is expected to drastically change the system's operation, as through train service between the Reading and Philadelphia Districts will be possible. The link between the two previously separate networks will improve the rail system's coverage and thus increase the

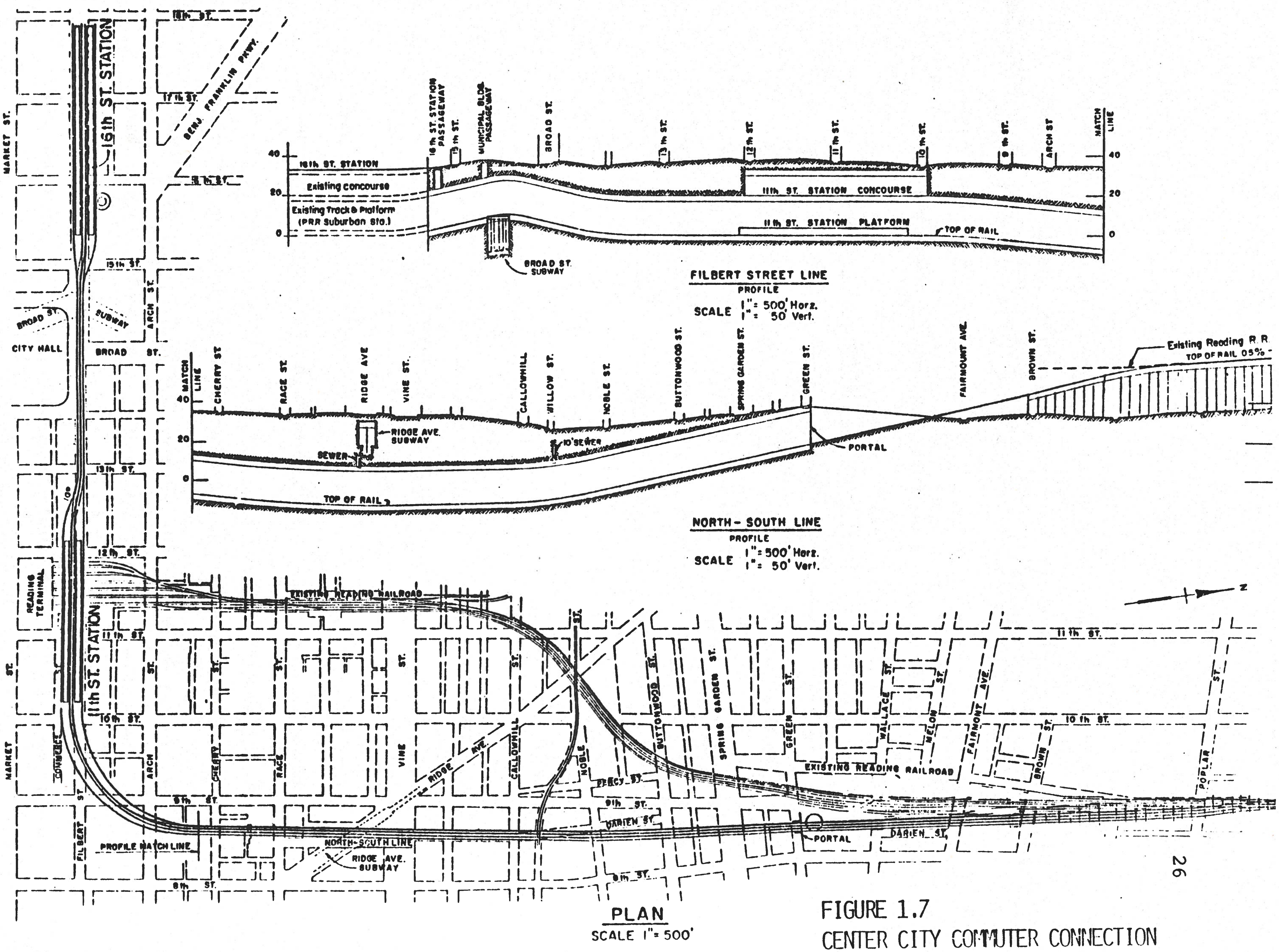


FIGURE 1.7
CENTER CITY COMMUTER CONNECTION

ridership potential. From an operational perspective, the connection of the two networks presents an opportunity to speed up services, increase the commuter rail system's capacity and increase its productivity and value to the region. More importantly, however, the function of the rail system is likely to evolve from merely serving commuters traveling between the suburbs and downtown, to serving a wide variety of regional trips.

1.3.5 Stations and Parking

Including Reading Terminal and Penn Center Station, there are a total of 182 stations located throughout the commuter rail network in the Philadelphia region (see Figure 1-8). A total of ninety-eight of these stations are located on the Philadelphia District network and the other ninety are on the Reading District. The majority of the existing stations, 165 in all, are located on branch sections of the network and are served by a single commuter rail line. The remaining seventeen are located on trunk sections of the network and are generally served by two or more lines. In the Philadelphia District network, for example, there are three major stations, namely, Penn Center, 30th Street and North Philadelphia which are served by more than one line. On the Reading District, all of the fourteen stations south of North Hills on the Reading trunk line on in to Reading Terminal are served at increasing rates by two or more lines.

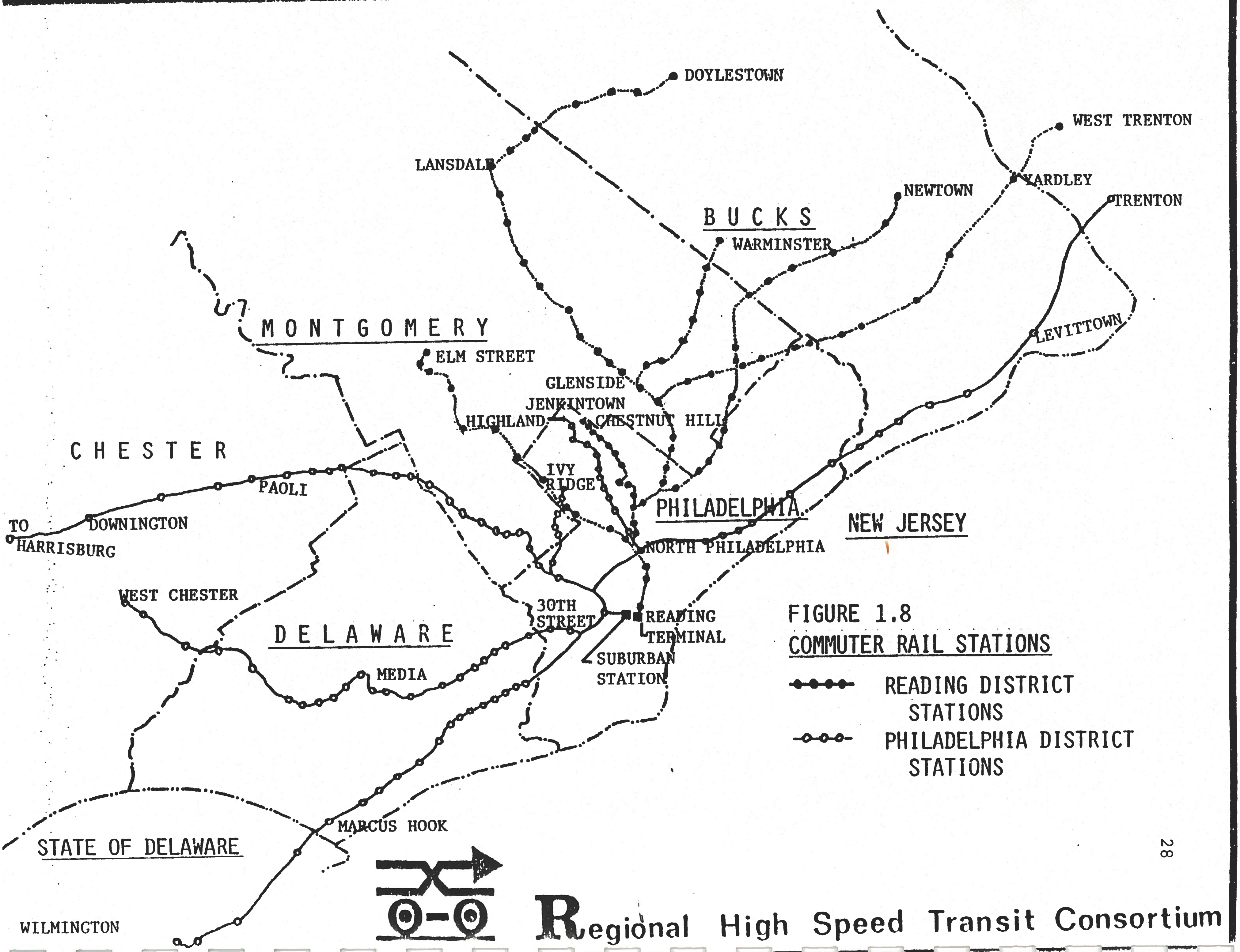


FIGURE 1.8
COMMUTER RAIL STATIONS

Figure 1-9 shows the number of stations served by each of the system's twelve operating lines. In the left-hand column, the station count is presented on a line-by-line basis without adjusting downwards to compensate for double counting of stations served by more than one line. The figure also shows the number of stations per line adjusted to avoid double-counting stations, thus reflecting the actual number of stations on the system. Accordingly, on a line-by-line basis, there are 235 stations served by the twelve lines, of which 103 are on the Philadelphia District and 132 on the Reading District.

The present commuter rail stations vary in design, size, physical condition and passenger amenities and services available to passengers. The station buildings range from the impressive neoclassic building at 30th Street Station in West Philadelphia (the region's major Amtrak station and a stop for all trains operating out of Suburban Station), to small station shelters at the periphery of the network which offer little weather protection and no amenities to waiting passengers.

The physical condition of the stations varies widely. Some stations are blighted and show the impact of years of deferred maintenance. Others are in relatively good condition and in many cases have been renovated as part of SEPTA's Station Modernization Program. The passenger services provided also vary from station to station. While

Figure 1-9

Commuter Rail Stations by Line and Systemwide

	Total Number of Stations (Unadjusted)	Number of Stations Adjusted for Double Counting
Philadelphia District		
Wilmington	16*	16
West Chester	25	23
Paoli	24**	22
Manayunk	8	6
Chestnut Hill West	13	10
Trenton	17	15
Subtotal Philadelphia	103	92
Reading District		
Norristown	16	12
Chestnut Hill East	17	13
Fox Chase/Newtown	21	14
West Trenton	26***	13
Warminster	21	7
Lansdale/Doylestown	31	31
Subtotal Reading	132	90
TOTAL	235	182

* To Marcus Hook Station
** To Downingtown Station
*** To West Trenton Station

Source: Delaware Valley Regional Planning Commission, Commuter Rail Statistics Project--Passenger Data, May 1982, pp. 1-42.

some stations, for instance, have ticket agents during normal business hours, others only provide the service during a few hours, and many others do not have ticket sales at all. At some station buildings, there is joint use with a section of the building leased for non transit-related businesses in exchange for maintenance and upkeep of the station.

Most of the existing stations have low level platforms. Only seven stations, including Suburban Station and 30th Street Station, have high level platforms.

To promote wider use of the system, most commuter rail stations provide parking for passengers. During 1982, it was estimated that a total of 15,000 off-street parking spaces were available at stations throughout the system. At existing stations, the number of parking spaces provided ranged from six spaces to a few hundred. In addition it has been estimated that some 3,500 on-street parking spaces located nearby the commuter rail stations may be used daily by commuters.

1.3.6 Track and Station Ownership

The ownership of the commuter rail trackage and stations in the region involves some five separate entities as summarized below. On the Reading and Philadelphia Districts:

--Amtrak owns the track and stations on the Paoli, Wilmington and Trenton lines as part of the Northeast Corridor. Chestnut Hill West and Manayunk trains operate on Amtrak-owned trackage for a portion of their journey.

--Conrail owns the track and stations from Neshaminy Falls to West Trenton on the West Trenton line and between Tabor Junction and Cheltenham Junction on the Fox Chase-Newtown line.

--NJ DOT owns the West Trenton Station on the West Trenton line.

--The City of Philadelphia owns a one-thirtieth share of the SEPTA-owned trackage within the city.

--SEPTA owns the remainder of the system.

Figure 1-10 summarizes track ownership by line. This information is also shown on the map in Figure 1-11.

As Figure 1-10 shows, there are a total of 124.3 unduplicated track miles, of which 83.7 are owned by Amtrak and the remaining 40.6 by SEPTA. The total unduplicated line mileage for the Reading District network is 93.1, of which 75.4 are owned by SEPTA and 17.7 by Conrail. Since Conrail operates freight service over segments of SEPTA-owned lines, Conrail pays SEPTA a portion of the maintenance and operating expenses for the jointly-used segment of the line according to a usage-based formula. Similar agreements are in effect between SEPTA and Amtrak concerning the use of Amtrak property by SEPTA.

1.3.7 Track Characteristics and Conditions

Figure 1-12 shows selected data on the track characteristics on the Philadelphia and Reading District networks.

The track conditions on the existing system vary from line to line. On the Amtrak main lines to New York (Trenton), Washington (Wilmington), and Harrisburg (Paoli), the

Figure 1-10

Track Ownership and Mileage

	Ownership	Line* Miles	Unduplicated Miles**
Philadelphia District			
Wilmington	SEPTA	2.1	2.1
	Amtrak	24.6	24.6
Media/West Chester	SEPTA	27.5	25.4
Chestnut Hill West	SEPTA	9.0	8.1
	Amtrak	3.0	3.0
Trenton	SEPTA	2.4	0
	Amtrak	30.0	27.0
Paoli/Downingtown	SEPTA	3.2	0.8
	Amtrak	29.1	29.1
Manayunk	SEPTA	7.4	4.2
	Amtrak	0.8	0
Subtotal		139.1	124.3
SEPTA		51.6	40.6
Amtrak		87.5	83.7
Reading District			
Lansdale/Doylestown	SEPTA	34.4	34.4
Chestnut Hill East	SEPTA	10.8	5.8
Norristown	SEPTA	18.0	14.7
Warminster	SEPTA	20.1	8.3
West Trenton	SEPTA	18.2	10.2
	Conrail	14.3	14.3
Fox Chase/Newtown	SEPTA	7.7	2.0
	Conrail	3.4	3.4
Subtotal		126.9	93.1
SEPTA		109.7	75.4
Conrail		17.7	17.7

* Line miles is the distance between the terminal and the end of each line.

** Unduplicated miles consist of line mile distances per line adjusted downward to reflect the joint use of the track on trunk sections of the network.

Sources: SEPTA, "Commuter Rail Statistics by Line Ownership," undated, pp. 1-4.

Rail Contingency Plans: Alternative Mobility Options for the Delaware Valley, op. cit., pp. 7-8

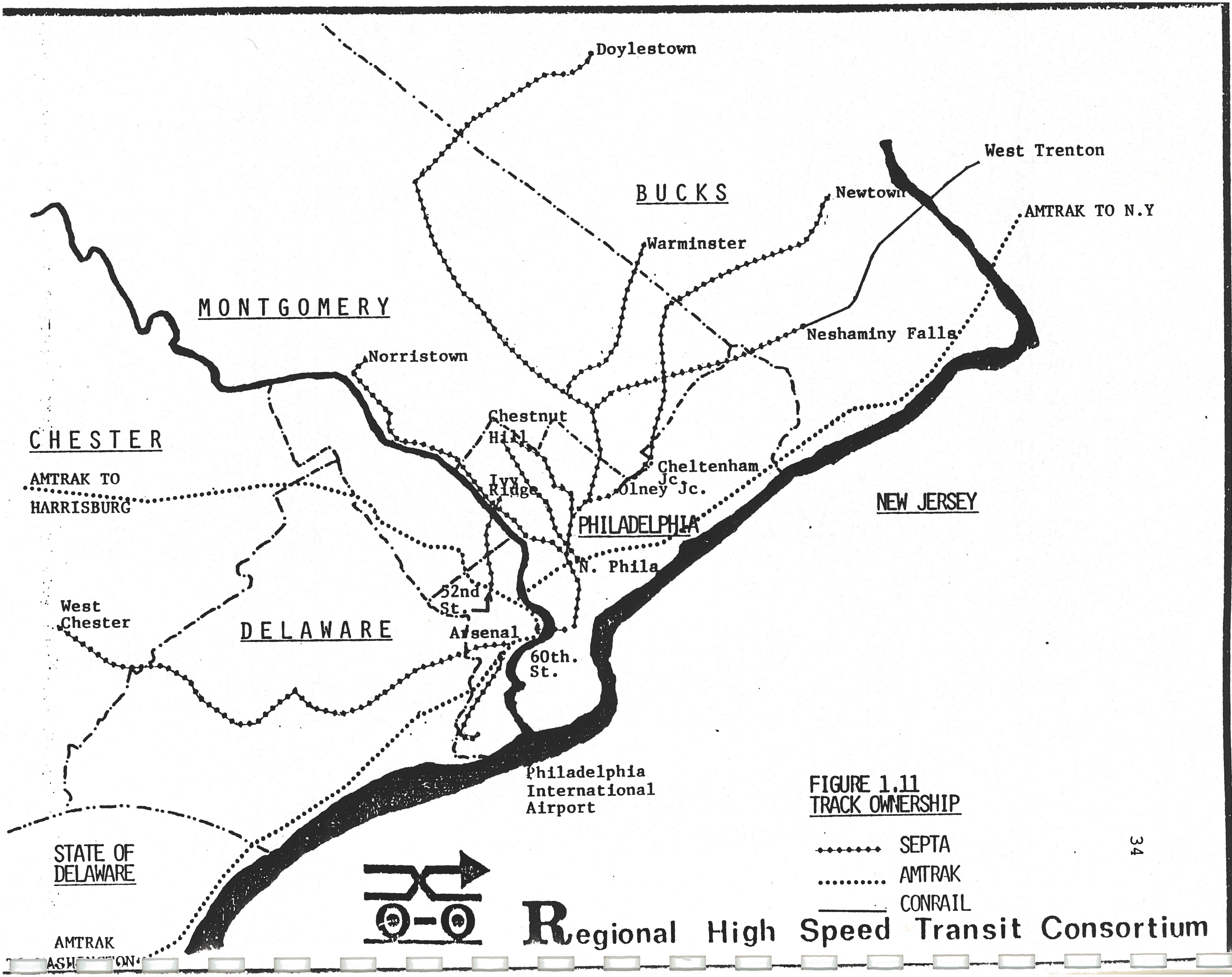


FIGURE 1.11
TRACK OWNERSHIP

Regional High Speed Transit Consortium

Figure 1-12

Physical Characteristics of Track by Line

	No. of Tracks	Rail Used (lb./yard)	Max. Grade	Max. Curv.	No. of Highway Crossings
Philadelphia District					
Wilmington (Penn Center to Wilmington)	2,1	130-150	.55%	1°30'	0
Media/West Chester (Arsenal to West Chester)	2,1	100-130	1.19	4°00'	20
Paoli/Downington (Zoo Junction to Downington)	4,3	130-150	1.54	5°00'	0
Manayunk (52nd Street to Ivy Ridge)	2,1	130	2.37	6°00'	0
Chestnut Hill West (North Phila. to Chestnut Hill)	2	100-140	2.50	6°00'	0
Trenton (Zoo Junction to Trenton)	4	130-150	.60	4°00'	0
Reading District					
Norristown (16th Street Jc. to Elm Street)	2,1	130	1.32	6°00'	16
Chestnut Hill East (Wayne Jc. to Chestnut Hill)	2	130	1.50	10°00'	0
Fox Chase/Newtown (Newtown Jc. to Newtown)	2/1	100-130	1.70	7°30	20
West Trenton (Jenkintown to West Trenton)	2,3	130-140	.68	3°00'	11

Figure 1-12 (continued)

	No. of Tracks	Rail Used (lb./yard)	Max. Grade	Max. Curv.	No. of Highway Crossings
Warminster (Glenside to Warminster)	2,1	130	1.50	4°30'	14
Lansdale/Doylestown (Reading Terminal to Doylestown)	4,2,1	130-140	3.20	7°00'	28

Sources: "SEPTA Commuter Region Line Diagrams," *op. cit.*, pp. 1-25

SEPTA, *SEPACT Final Report: A Study of the 1975 Commuter Railroad System in the Southeastern Pennsylvania Metropolitan Region*, 1971, pp. 25 and 35

SEPTA, "Grade Crossing Inventory," undated, pp. 1-2 physical condition of the track has improved substantially over the years as Amtrak has undertaken a number of track improvements as part of the Northeast Corridor (NEC) Improvement Program, and now permits high-speed operation. Beyond Amtrak's NEC lines, however, the track conditions are generally less than adequate, as much of the existing track consists of old jointed rail laid on old ties or mud-fouled ballast. The track condition is reflected by the numerous slow speed orders and speed restrictions put in effect due to poor track.

During the second half of 1982, for example, it was estimated that 46 route miles of track, or 18 percent of the total system's route miles, were operated under speed reduction orders due to poor track conditions.[8] In response to this problem and its adverse impacts on service reliability, SEPTA has accelerated the implementation of a program of right-of-way improvements and rail renewals, a program specifically designed to meet the most pressing track needs in the system and to reduce the mileage operated under reduced speed orders.

1.3.8 Signal System

With few exceptions, all trackage on the existing commuter rail network has automatic block signalling (ABS). This system consists of a series of consecutive blocks governed by wayside signals, cab signals, or both, actuated by a train or certain conditions affecting the use of the block. The only non-ABS sections on the existing network are on the West Chester Branch between Elwyn and West Chester and on the Fox Chase-Newtown Branch between Fox Chase and Newtown. These two sections use manual block signalling.

Two general types of signal display are used on the existing commuter rail network: wayside and cab signals. Except for the non-ABS sections noted earlier, wayside signals are used throughout the system to convey information on block occupancy. The wayside signals are displayed differently on the Philadelphia and Reading District networks. On the Reading District, signals are displayed by regular red, yellow and green color lights. On the Philadelphia District, signals are shown by groups of three amber lights which may be in a horizontal, vertical or 45-degree angular position, indicating "stop," "proceed" and "caution," respectively. Despite the difference in signal display between the two districts, Reading District trains can generally operate on the Philadelphia District and vice versa.

Due to safety considerations and the regulation of Amtrak operations by the Interstate Commerce Commission (ICC), on the Amtrak main lines signals are shown both on the engineer's display panel and at wayside locations. The cab signals provide continuous information on the track's block occupancy, independent of weather conditions and other obstructions to wayside signal visibility. Most of the SEPTA commuter fleet is equipped with the necessary circuitry to pick up and display the signals when operating through cab signal territory. As part of the Center City Connection Project, all commuter cars lacking this capability will be retrofitted with this equipment.

In response to the anticipated operation of the center city tunnel, a number of signalling improvements are underway or have recently been completed. These projects are generally designed to reduce the potential for train congestion and safety hazards on the trunk line between 30th Street Station, the tunnel and Jenkintown. The improvements involve the installation of cab signal circuitry and other hardware in the track between Suburban Station and Wayne Junction to permit cab signal operations and reverse running on the entire trunk line. The new Airport High Speed Line (AHSL) will also be provided with equipment for cab signal operations.

1.3.9 Electric Traction Power

The Pennsylvania Railroad in the 1910's and the Reading in the 1920's began to electrify their Philadelphia area commuter rail lines. By the end of the 1930's virtually all passenger service in the region had been electrified. Today only one section of the active network, between Fox Chase and Newtown on the Fox Chase/Newtown line, remains unelectrified. This section is served by Rail Diesel Cars (RDCs) as opposed to the multiple unit equipment used on the rest of the system. Until 1981 there was non-electrified service between Lansdale and Quakertown on the Bethlehem Branch and between Norristown and Pottsville on the Reading's main line to Reading. Commuter service on these two sections was discontinued in 1981.

The electrified lines use an overhead catenary system which is fed approximately 11,000 volts of 25-cycle alternating current (A.C.). Cars pick up the electricity by means of pantographs mounted on the vehicle roof. The fleet is equipped with rectifiers to change A.C. into direct current (D.C.) for the cars' traction motors.

Ownership and responsibility for the electric power system, its maintenance and improvement are shared by Amtrak and SEPTA. On the Philadelphia District, all electrical facilities used for Amtrak's main lines to Harrisburg, Trenton and Wilmington are Amtrak-owned and controlled. On the other Philadelphia District lines to Chestnut Hill West, Manayunk and Media/West Chester, all electrical facilities are tied into the Amtrak system and controlled by Amtrak dispatchers. On these lines, Amtrak is responsible for maintaining the catenary, even on the SEPTA-owned portions of the line. SEPTA in turn has contractual agreements with Amtrak concerning the use and cost of power used for SEPTA service.

On the Reading District, the overhead catenary over SEPTA-owned trackage and substation facilities is owned by SEPTA. Until January 1, 1982, Conrail was responsible for the maintenance of the electrical system. This, however, is now SEPTA's responsibility. Also, SEPTA is responsible for the sponsorship of all capital improvements to the system outside the Northeast Corridor main lines.

1.3.10 Rolling Stock

In 1983 the active commuter rail car fleet consisted of 359 electric multiple unit cars plus eight rail diesel cars and two locomotives. In 1983, the equipment ranged in age from eight to fifty-two years. However, 64 percent of the multiple unit cars are only eight years old. As shown in Figure 1-13. A total of 191 cars are currently assigned to the Philadelphia District lines and 176 cars plus two locomotives to the Reading District lines. The eight self-propelled RDC cars assigned to the Reading District are used on the non-electrified Fox Chase-Newtown line.

The multiple unit electric equipment is comprised of nine-two semi-permanently coupled married pairs (184 cars) which share selected components such as batteries, air compressors and pantographs with each other and cannot operate as single units; and 175 cars which can operate as single units or in a train consist. The combination of married pairs and single unit cars allows for maximum flexibility in the assignment and use of cars on the various lines.

Figure 1-13

Commuter Rail Rolling Stock

Type	Type of Unit	Year Built*	Number	Cars Assigned Per District Reading	Cars Assigned Per District Philadelphia	Total
Silverliner IV	married pairs	1975	92	102	129	231
	single units	1975	47			
Silverliner III	single units	1967	20	0	20	20
Silverliner II	single units	1963	54	17	37	54
Silverliner I	single units	1953	5	0	5	5
Rehabilitated	single units	1931	38	38	0	38
Green	single units	1931	11	11	0	11
Rail Diesel	single units		8	8	0	8
Locomotives	single units	1956	2	2	0	2
Total (excluding locomotives)				176	191	367

*Estimated Average Age

Sources: J. R. Pawson, Delaware Valley Rails: The Railroad, and Rail Transit Lines of the Philadelphia Area, 1979, pp. 60-61.

SEPTA "Capital Grant Application for FRA/EPA Mandated Car Modifications== Phase II Program," submitted to UMTA in April of 1981, Project Description.

The multiple unit cars have single doors in the vestibules at the ends of the car and allow for boarding and alighting from both low and high level station platforms. On the newer Silverliner IV cars, provision has been made for the future installation of sliding center doors. All Silverliner cars have transverse seats, mostly in a 3 and 2 arrangement. There are only ten Silverliner III cars with 2 and 2 seating. Seating capacity for the old and rehabilitated cars range from 80 to 86; for the Silverliner I, II, III and IV cars it ranges from 100 to 129 seats.

Presently, car maintenance for the Reading District car is performed at the Wayne Junction shop. The Philadelphia District equipment is maintained at the Paoli shop, a facility built in 1915 and later expanded to meet growth in the system. SEPTA owns both the Wayne Junction and Paoli shops.

1.4 Commuter Rail Services, Cost, Financing and Management

Between 1971 and 1981 the Philadelphia metropolitan region felt the impacts of five major trends in the operation, management and financing of commuter rail service. First, the region experienced a gradual reduction in the quality and quantity of service provided. Second, the direct operating costs of providing the service increased sharply. Third, the total revenues available to finance the system's operations, i.e. farebox receipts and local, state and federal government subsidies grew significantly, but barely kept pace with annual increases in the loss of operations. Fourth, the public subsidy requirement for the system's operation increased substantially as the gap between annual revenues from passengers and annual operating costs widened. And fifth, the management of the system evolved over time in efforts to gain more effective control over the operation and finance of the system. This section describes and analyzes the commuter rail services, operating and capital costs, financing and management. Most of the information covers the period between 1971 and 1981, for which adequate data was available. The section concludes with a general description of the most pressing long-term operating problems facing the region's commuter rail system.

1.4.1 System Ridership and Level of Service

The overall ridership for the twelve lines in the system has declined substantially over the last few years. On an annual basis, for example, total ridership for the system fell from approximately 32.3 million trips in 1980 to 28.6 million in 1981 and 24.1 million in 1982.[9] This amounts to a decline of 8.2 million trips over three years. Much of this decline has resulted from general deterioration in the level of service, as shown by service reductions, line discontinuances and fare increases.

The ridership losses have been distressingly high between 1981 and 1982, when a number of fare increases and service reductions went into effect to avert the financial collapse of the system. Figure 1-14 shows the average weekday ridership for November 1981 and May 1982 for the twelve lines.

The ridership data on this figure shows that over the six months between November 1981 and May 1982, the system's average daily ridership decreased by 6200 one-way trips from 96,200 to 90,000. This decline can directly be attributed to two major factors: (1) Service cuts which during the fiscal year ending in June 1982 amounted to a reduction of 1/3 of the train miles operated, or a 30 percent cut of all scheduled weekday trains operated in the previous years; and (2) Fare increases which between July of 1980 and January of 1981 alone went up by 62.5 percent. It is interesting to note that the fare increase during the second half of 1980 led to a loss of about 20 percent of the daily ridership. This reduction in turn was followed by a 30 percent reduction in train service.[10]

Despite the service cutbacks and fare hikes of recent years, the lines' ranking in terms of ridership remains unchanged. On the Philadelphia District, the Paoli and West Chester lines consistently show the greatest ridership over the four lines. The Manayunk line has the fewest riders. On the Reading District, the Lansdale/Doylestown and Warminster lines are the best performers, while the Norristown line shows the lowest ridership on the entire Reading District.

Figure 1-14

Average Weekday Ridership by Line*

	November 1981	May 1982	Change
Philadelphia District			
1. Wilmington	8,900	9,000	+ 100
2. Media/West Chester	14,200	13,300	- 900
3. Paoli	22,100	18,500	-3,600
4. Manayunk	1,400	1,400	0
5. Chestnut Hill West	8,900	8,900	0
6. Trenton	8,100	7,200	- 900
Subtotal	63,600	58,300	-5,300
Reading District			
7. Norristown	2,800	2,400	- 400
8. Chestnut Hill East	5,000	4,600	- 400
9. Lansdale/Doylestown	7,800	7,800	0
10. Warminster	6,200	6,000	- 200
11. West Trenton	5,700	5,600	- 100
12. Fox Chase/Newtown	5,100	5,300	+ 200
Subtotal	32,600	31,700	- 900
Total System	96,200	90,000	-6,200

*All figures are rounded off to the nearest 100.

Source: Delaware Valley Regional Planning Commission, Commercial Rail Statistics Reports, Fal 1981 and Spring of 1982, Company Summary Tables

The level of service provided on each of the twelve lines in the region varies in terms of frequency and capacity provided. In May 1982, peak period service frequencies ranged from ten to fifteen minutes on the most heavily traveled line, the Paoli line, to thirty minutes on the Manayunk line, the least traveled. Daily off-peak service frequencies ranged from thirty to sixty minutes. Service is also provided on most lines during weekday and weekend off-peak hours, but at significantly reduced levels. The reduced level of weekend service reflects patronage, which drops considerably during the weekend. Saturday ridership is 30 percent of the weekday daily average and on Sunday the proportion drops to 15 percent.

As documented in ridership surveys, some 87 percent of all inbound daily trips are oriented towards Center City Philadelphia; i.e. Reading Terminal, Suburban Station or 30th Street Station.[11] Furthermore, more than 60 percent of all daily inbound riders use the system during the two-hour inbound peak. In addition, some 90 percent of all trips are work related. This shows the existing system's strong suburban-downtown commuter orientation. As noted earlier, this orientation and function is likely to change with the opening of the Center City commuter tunnel and the increased connectivity and accessibility that it will provide throughout the region.

1.4.2 Commuter Rail Fares

Existing commuter rail fares use a zonal system based on Center City Philadelphia. Each line has several zones with fare increments based on the number of zones traversed. Presently there are several types of fares tailored to meet users' needs. Riders can choose from a selection including one-way and round-trip rush-hour and off-peak tickets, ten-trip tickets, and the recently-introduced TrailPass, a monthly rail pass which also allows use of SEPTA's City Transit Division and one Suburban Transit Division fare zone at no extra cost.

The fare cost for regular riders varies depending on the type of ticket purchased, the number of zones that crossed and, in some cases, the time of the day the trip is taken. Currently the most expensive fare is the one-way peak hour ticket which ranges in price from $1.50 for a trip within the terminal zone in Philadelphia to $5.00 for a trip between the terminal zone and Zone 7 or vice versa. The least expensive fare is potentially given by the monthly TrailPass which allows an unlimited number of trips on the commuter rail system between Philadelphia, the zone for which the TrailPass was purchased, and intermediate points. Beginning in July 1982, Senior Citizens were able to ride the system free during off-peak hours.

1.4.3 System Operating Costs and Financing

In the last ten years (1971-1981), the region has witnessed an unprecedented escalation in the direct costs of commuter rail service operation. At the same time, the quality of service has declined to a level which fails to meet the needs of passengers, the community and the region itself. The financing of commuter operations has also become an issue of critical concern for the region as the financing sources, i.e. farebox revenues and public subsidies have barely kept pace with the increased annual cost of operations. This section deals with the operating costs and financing of the commuter rail system. Emphasis is placed on highlighting the major issues facing the region as they relate to system operations and financing.

1.4.3.1 Operating Costs. Between 1971 and 1981, the direct annual operating cost of commuter rail service in the Philadelphia region grew from $32.6 million in 1971 to $113.2 million. This represents an increase of more than 240 percent over the ten-year period. As shown in Figure 1-14, the escalation of operation costs is particularly evident during the five years when Conrail ran the trains.

Several factors have contributed to the increased cost of operating the service over the last ten years. First, the federal legislation creating Conrail discontinued the previous practice whereby the operating railroads absorbed a small portion of the operating expenses incurred in providing the

Figure 1-15

Commuter Rail System Operating Costs, Revenues, Deficits and Subsidies
(Selected Years 1971-1981)

Year	Annual Operating Costs	Annual Revenues from Passengers	Annual[1] Operating Deficit	Annual Operating Subsidies	Annual[2] Unfunded Deficit	
			(Millions)			
1971	33.6	20.0	13.6	9.6	4.0	3
1973	40.5	22.5	18.0	14.5	3.5	
1975*	50.3	22.4	27.9	22.0	5.9	
1977	73.1	29.3	43.8	43.3	.5	5
1979	82.7	33.7	49.0	46.9	2.1	
1981	113.2	46.6	66.6	53.8	12.8	

*Rail Line Acquisition by SEPTA, Service Operation by Conrail

1. Annual Operating Deficit is defined as the difference between Annual Operating Costs and Revenues from Passengers.
2. Annual Unfunded Deficit is the difference between Annual Operating Costs and total system revenues including receipts from the farebox and Annual Operating Subsidies.
3. Prior to 1976 the Operating Railroads absorbed the unfunded deficit as an operating loss. For instance, between 1971 and 1976 it is estimated that the railroads did not pass on to SEPTA, approximately $23.5 of the operating costs incurred in providing commuter rail service in the region.
4. After 1976 the operating deficit grew as Conrail was mandated by Congress to pass on to SEPTA and other transit authorities with operating contracts with Conrail the full actual cost of provising the service.
5. According to Conrail by 1981 there was a cumulative unfunded deficit of approximately $53.0 million for unpaid operating costs for the period between 1976 and 1981 inclusively. In 1981, however, SEPTA reached a settlement with Conrail whereby SEPTA paid Conrail $9.6 million out of the $53.0 claim and Conrail recorded a loss of -43.4 million. Funding to cover the unfunded deficit has come from contingency funds and working capital of the Commuter Rail Division and advances from SEPTA's City Transit Division

Sources: SEPTA, "Presentation before the House Select Committee to Investigate SEPTA," August 1980, Exhibit 4.

SEPTA, Fiscal Year 1981 Annual Report, November 1982, pp. 1-17.

service. Under the new legislation, Conrail was mandated to charge the full cost of operating commuter rail sources. As a result, between 1975 and 1977 alone there was a 29 percent increase in the expenses reported by Conrail to be paid by SEPTA. Second, the high operating cost structure for the railroads Conrail took over reflected extremely low productivity and efficiency of labor and other resources. Third, there were no budgetary or financial controls to effectively curb rising operating costs. Fourth, the continued deterioration of the physical plant led in turn to even higher operating costs. And fifth, the rate of inflation, which according to the Consumer Price Index grew at average annual rates of 9.5 percent over the ten-year period,further raised costs. Altogether these factors led to an annual system operating cost, which by 1981 almost exceeded the financial capability of the region.

1.4.3.2 Operating Revenues and Subsidies. The sources of finance for the system's operation come from farebox and public subsidies. Operating subsidies are currently provided by the federal and state governments, and the five counties in the commuter rail service area. The operating subsidies cover the difference between the annual cost of providing an agreed upon level of service, as per SEPTA operating agreements with Conrail and its predecessors, and the annual gross revenues generated from the farebox.

As shown in Figure 1-15, the annual farebox revenues have increased over time, though at average rates lower than those of operating costs. Mostly as a result of substantial fare increases, the passenger's share of revenues has been increasing significantly since 1977. Despite the increase in farebox receipts, the gap between farebox revenues and operating costs,--the operating deficit--, has widened and, therefore, there has been a corresponding high increase in the subsidies required from federal, state and local governments.

Formal public financing for commuter rail service began in 1958. At this time the City of Philadelphia agreed to subsidize the operation of two rail lines within the city in exchange for service improvements and fare reductions. Since then, subsidies have grown in terms of requirements, actors involved and sheer magnitude. Figure 1-15 shows a breakdown of the operating assistance required by source of funding during five selected years over the 1971-1981 period.

Beginning in 1974, federal assistance became available for operating deficits for both commuter rail and transit operations. By 1976 the federal legislation authorizing Conrail to operate rail commuter service provided special funds to cover a portion of the operating deficit for 1976 and 1977. By 1977, federal assistance covered close to 50 percent of the operating deficit. Since 1978, however, the proportion of federal funding for commuter rail

Figure 1-16

Commuter Rail Service Operating Subsidy Requirement by Source (1971-1981)

Year	Federal	State	Counties	Other	Total
		(millions)			
1971	--	6.4	3.2	--	9.6
1973	--	9.7	4.8	--	14.5
1975	2.5	13.0	6.5	--	22.0
1977	20.3	15.4	7.6	--	43.3
1979	19.5	18.2	9.1	.14	46.8
1981	15.4	26.1	12.2	.14	53.8

Sources: Commuter Rail Contingency Plans: Mobility Options for the Delaware Valley Region, op. cit., p. 18.

J. R. Pitts, et al., Report to the House Select Committee to Investigate SEPTA, January 1980, p. 120.

operations has decreased substantially. By 1981, federal funds covered less than 30 percent of the total deficit and there are indications that the federal operating assistance program will be phased out over the next few years.

The remaining commuter rail operating deficit not funded by the federal government is made up by the Commonwealth of Pennsylvania, the City of Philadelphia and the four suburban counties. Under the state's financial assistance program, the state can pay up to two-thirds of the local operating deficit (total deficit minus federal operating assistance). Due to the manner in which state funds are distributed to SEPTA's divisions, the state commuter rail subsidy may in fact exceed the two-thirds level. The portion of the deficit not funded by the federal or state governments is provided by the City of Philadelphia and the counties of Bucks, Chester, Delaware and Montgomery. Each of the five local participants has informal agreements, which are not legally binding, to fund a percentage of the local deficit (total deficit less state and federal subsidies). The formula currently used to distribute local subsidy requirements is based on vehicle miles traveled within each jurisdiction. The local deficit is allocated as follows: Philadelphia--70 percent; Bucks--5.9 percent; Chester--4.3 percent; Delaware--8.8 percent; and Montgomery--11 percent.

A major trend over the last ten years (1971-1981) has been increased for federal, state and local participation in funding the commuter rail operating deficit. This deficit has grown over time because on the average annual passenger revenues have not risen at the same rate as the annual cost of operating the system.

The obligations for funding the operating deficit have shifted significantly over the last ten years. Federal subsidies for commuter rail operations, for example, began in 1974. Between 1974 and 1978, the federal government funded an increasingly higher share of the operating deficit. By 1978, the federal contribution amounted to nearly 51 percent of the deficit. Since then, however, federal support for commuter rail operations has fallen off. As a result, the local governments and the state have had to bear an increasingly higher share of the funding. Should the federal operating subsidies be totally eliminated over the next three years, as planned, it is unlikely that the state and local governments can adequately provide for and sustain the operation of the system from traditional funding sources.

1.4.4 System Capital Costs and Funding

Due to the current deteriorated condition of the physical infrastructure, SEPTA and the region need massive funding for capital improvements. In the last twelve years the region has obtained some $609 million for commuter rail-related improvements. As shown in Figure 1-17 much of this money has gone for the construction of the Center City Commuter Connection and the Airport High Speed Line, and acquisition of new rolling stock. Despite past capital improvements to selected commuter rail system components, the total capital need for the system is staggering, as essential system components such as signal and electrical systems, track, maintenance facilities and others have deteriorated due to age and continued use. According to the FY 83 SEPTA Capital Program, some $322 million will be needed between 1983 and 1988 to meet the most critical capital needs of the commuter rail system.

Financing capital improvements for the region involves federal, state and local governments. Section 3 of the

Figure 1-17

Commuter Rail Projects Funded Prior to FY 1983

Project	Funding Prior to FY 1983 (in millions)	Estimated Total Cost (in millions)	Status
144 Commuter Rail Cars	$ 58,967	$ 58,967	Complete
88 Commuter Rail Cars	69,376	69,376	Complete
Conrail Acquisitions (ROW's)	10,544	11,544	Complete, except for a small segment which SEPTA plans to purchase at a later date
Hatboro-Warminster Line Improvements	2,513	2,513	Complete
Commuter Stations and Parking (I and II)	9,910	17,200	Most stations to be rehabilitated in Phase I have been improved. Phase II Engineering is scheduled for FY 1983
Center City Commuter Connection (CCCC Project)	289,250	325,000	Construction underway. To be completed in FY 1983
Commuter Car Rehabilitation Program--Phase I and II	3,800	6,340	Work is underway on Phase I of the Program
FRA/EPA Mandated Car Modifications Program (Phases I, II, III and IV)	7,241	16,800	Work is underway on the Phase I modifications. Additional work is scheduled for FY 1983.
Commuter Operation Facilities Modernization (COFM) I and II	33,625	167,700	Work is underway on Phase I and II of the Program

Figure 1-17 (continued)

	Funding Prior to FY 1983 (in millions)	Estimated Total Cost (in millions)	Status
Commuter Railroad Facilities Coordination	$ 46,447	$ 59,027	Work is underway
Airport High Speed Line (AHSL)	78,000	91,500	Line due to open in Fiscal Year 1983.
TOTAL	$ 609,673	$ 825,967	

Sources: Commuter Rail Contingency Plans: Alternative Mobility Options for the Delaware Valley, op. cit., p. 20.

SEPTA, FY 82 and FY 83 Capital Programs

Urban Mass Transportation Act of 1964, as amended, allowed the Urban Mass Transportation Administration to make discretionary grants to help transit agencies implement capital improvements. Subsequent amendments to the UMTA Act have generally increased the amount of funding available for capital projects.

Before the enactment of the Surface Transportation Assistance Act of 1982, the federal government provided funding for 80 percent of the total cost of a commuter rail project. The remaining 20 percent was provided by the Commonwealth of Pennsylvania at 16-2/3 of the total project cost, and the City of Philadelphia and four suburban counties put up 3-1/3 of the total project cost. The allocation of this 3-1/3 percent among the city and counties involved the same formula used to allocate local costs for the operating subsidy.

The Surface Transportation Assistance Act of 1982, passed by Congress in late 1982, contains several changes in capital project funding which will no doubt have an adverse impact on the region's ability to finance new improvements. Chief among these changes is the reduction authorized in the federal share for the Rail Modernization Program under Section 3 from 80 percent to 75 percent of the total project cost. This change will increase the state and local contributions to make up the difference.

At the state level there also has been some discussion about reducing the state share for capital projects from the present 16-2/3 to 10 percent of the total project cost. Under the worst scenario, the local governments may be faced with a change from the past 3-1/3 percent contribution towards capital projects to 15 percent. In light of the financial problems facing all governments in the region, it will be nearly impossible to find local funding sources to cover this potential shortfall. Therefore, a major source of future concern will not be so much the availability of federal money, as the region has generally been assured of receiving federal capital funds, but rather will be finding additional state and local funds to match federal funding capital improvement grants.

1.4.5 System Management

The management and administration of commuter rail services in the Philadelphia region has been SEPTA's responsibility since the mid-1960's. Up to January 1983, the management structure for the system was quite simple, as SEPTA managed and administered the service, while Conrail's predecessors and Conrail operated the system under contract to SEPTA. Within SEPTA the responsibility for the services management has rested with the Regional Rail Division. This division, created specifically to monitor and administer the commuter service contracts, operated until 1981 when it was merged with the other SEPTA transit divisions.

The management of the commuter rail service in the region can be characterized as crisis-oriented and plagued by dissent between the two main participants, SEPTA as the sponsor; and Conrail as the operator. Beginning in 1976, SEPTA contracted with Conrail to operate commuter service in the region. Under the operating agreement, Conrail was to have "exclusive control of management operation while SEPTA was to be responsible for setting train schedules, the fare structure and level and the performance standards." However this arrangement posed several problems for SEPTA:

--SEPTA could not make Conrail comply with established performance standards. Conrail was to be reimbursed for all costs incurred in the provision of service.

--The operating contract did not have provisions for the control of the operating budget.

--In the absence of cost controls and enforceable service standards, the cost of providing the service increased while its quality and quantity decreased.

In response to the serious commuter rail fiscal problems in 1979 and 1981, in 1981 SEPTA began to explore the possibility of taking over the service or contracting it out to other operators. By the end of 1981, with the enactment of the Northeast Rail Services Act, Conrail was relieved of any further obligation to provide commuter rail service after January 1, 1983. During early 1982, SEPTA faced a major management issue: whether the service was to be operated by an Amtrak subsidiary, the Commuter Rail Service Corporation, or directly by SEPTA. By the end of 1982, it became evident that SEPTA would operate the service itself.

Since January 1983, Philadelphia area commuter rail operations and management have been consolidated for the first time under SEPTA's transit divisions. Between January and March 13, 1983, SEPTA commuter rail service was operated by ex-Conrail employees who opted to work for SEPTA. During this period, these employees worked without a contract, as negotiations on wage rates, work rules and overall labor agreement was being negotiated between SEPTA management and the fifteen labor unions representing the ex-Conrail workers. On March 14, 1983, the commuter rail unions went on strike as a result of a failure to reach a satisfactory contract with SEPTA management. As of this writing, the commuter rail service shutdown has continued and there are few indications that a settlement may be reached soon.

At present, it is difficult to assess the long term impacts of direct SEPTA commuter rail management and operations. In the short run it appears that the consolidation of commuter rail operations under SEPTA will allow the transit agency to deal with fundamental issues of labor practices, system financing and costs, and management of the system itself. A SEPTA takeover, however, is not in itself the ultimate solution to the long term problems facing the commuter rail system. Their solution may require more drastic action. Before turning to this topic, we will examine these problems in greater depth.

1.4.6 Problems with the Existing Commuter Rail System

The importance of the existing commuter rail system to the social and economic fabric of the Philadelphia metropolitan region has long been recognized, and has served as a basis for local initiatives to keep the commuter rail services running. Support for the system is evident from the willingness of local governments to provide financial support for a segment of the system's capital and operating costs. In the last twenty years, however, rising costs and limitations to federal subsidies have placed considerable strain on state and local budgets. A number of potential rail shutdowns have been narrowly averted through service reductions and fare increases. While this strategy may lead to desired short term "gains" in the form of cost reductions and/or revenue increases, it is unlikely that in the long run this strategy will resolve the fundamental problems affecting the system.

There are numerous problems afflicting the existing network and hindering the creation of a modern, efficient system. The most basic problem is the system's physical condition. With a few exceptions, the physical plant is old and in need of replacement and/or upgrading. Under present conditions, the existing plant is expensive to maintain and has a low level of productivity due to the age and obsolescence of its components. The introduction of new technology into the system could not only reduce the system's operating cost but also improve the system's performance and increase its usefulness as a shaping force in metropolitan development.

A second problem is the role and function of the commuter rail system in meeting the transportation needs of the region. Due to the historical development of the railroads and the region, the existing network is radial and designed to connect outlying suburban communities with downtown Philadelphia. Over the last fifty years, however, the population and employment within the region have both grown and slowly but surely shifted location. Meanwhile, the commuter rail network has remained static with a predominantly downtown orientation despite ridership losses. The construction of the Center City Commuter Connection (CCCC) is at least a step towards meeting the region's changing transportation needs. With this facility, the region's accessibility will increase and the rail system will begin to serve regionwide transportation needs. But the CCCC project is only one of the improvements required to revitalize the system. Since it is evident that the system's survival depends on its ability to meet regional needs, it is imperative that the system link other major travel corridors than those currently served.

The third problem is that of the ridership level of and system costs. The present system is too expensive to operate, is poorly utilized, and is not competitive with other modes of transportation. Among the factors contributing to this condition are (1) the mode of management, which has been inadequate at times; (2) system financing; (3) low labor productivity and high labor costs; (4) the system's inability to maximize its utility by providing innovative services; and (5) inability to innovate and introduce new technology to reduce operating costs.

Unless these problems are addressed in the near future, this region will have to cut back and eliminate services rather than modernize and expand them. The study team proposes two alternatives which attempt to address the most fundamental problems of the Philadelphia metropolitan area's commuter rail system.

REFERENCES--CHAPTER 1

[1] J. R. Pawson, Delaware Valley Rails: The Railroads and Rail Transit Lines of the Philadelphia Area, 1979, p. 11.

[2] L. Grow, On the 8:02: An Informal History of Commuting by Rail in America, Mayflower Books, N.Y., 1979, pp. 120 and 124.

[3] *Ibid.*, p. 120.

[4] J.W. Boorse, Jr., Philadelphia in Motion: A Nostalgic View of How Philadelphians Traveled, 1902-1940, Bryn Mawr Press, Bryn Mawr, 1976, p. 48.

[5] T. Nelligan, "SEPTA's Philadelphia: Land of the Silverliners," Passenger Train Journal, February 1980, p. 34.

[6] *Ibid.*, p. 34.

[7] Montgomery County Planning Commission, A Plan for Revitalizing Commuter Rail Stations, 1972, pp. II-1.

[8] SEPTA, Fiscal Year 1981 Annual Report, p. 3.

[9] SEPTA, Ridership Data--1965-1982, pp. 1-2.

[10] Fiscal Year 1981 Annual Report, Op. Cit., p. 3.

[11] Orth-Rodgers and Associates, Inc., Commuter Rail Contingency Plans: Alternative Mobility Options for the Delaware Valley, Final Report, December 1981, p. 12.

BIBLIOGRAPHY--CHAPTER 1

Boorse, J. W., Jr. Philadelphia in Motion: A Nostalgic View of How Philadelphians Traveled, 1902-1940. Bryn Mawr Press, Bryn Mawr, 1976.

Bucks County Planning Commission. Comprehensive Plan, June 1977.

Chester County Planning Commission. Public Transportation Study-County Plan Element Number 1, January 1982.

Delaware County Planning Commission. Delaware County Land Use Plan 2000, January 1976.

Dorin, C. P. Commuter Railroads--A Pictorial Review of the Most Travelled Railroads. Superior Publishing Company, Seattle, 1970.

Grow, L. On the 8:02: An Informal History of Commuting by Rail in America. Mayflower Books, N.Y. 1979.

Montgomery County Planning Commission. A Plan for Revitalizing Commuter Rail Stations, 1972.

Nelligam, T. "Septa's Philadelphia: Land of the Silverliners." Passenger Train Journal, February 1980.

Orth-Rodgers and Associates, Inc. Commuter Rail Contingency Plans: Alternative Mobility Options for the Delaware Valley, Final Report, December 1981.

Pitts, et al. Report of the House Select Committee to Investigate SEPTA, January 1980.

Pawson, J. R. Delaware Valley Rails: The Railroads and Rail Transit Lines of the Philadelphia Area, 1979.

SEPTA. Fiscal Year 1980 and 1981 Annual Reports, November 1981 and 1982.

SEPTA. Fiscal Year 1982-1987 and 1983-1988 Capital Programs, July 1981 and 1982.

SEPTA. Operating Budgets--Fiscal Year 1982 and 1983. June 1981 and 1982.

SEPTA. "Report on the Conrail Crisis," 1981.

SEPTA. SEPACT II Final Report: A Study of the 1975 Commuter Railroad System in the Southeastern Pennsylvania Metropolitan Region, January 1971.

Tomazinis, A. R. "Some Thoughts about the Present Problems and the Future of the Commuter Railroads in the Philadelphia Region." Unpublished Paper, University of Pennsylvania, July 1982.

Vuchic, V. R. Urban Public Transportation Systems and Technology. Prentice Hall, Inc., 1981.

CHAPTER 2

LAND USE

by

John Allen, Carmen Blassini and Scott Gibbons

2.1 Land Use--Transportation Alternatives

by John Allen

This report proposes two possible improved passenger rail networks for the Philadelphia region. Both are based on the existing commuter rail system in large part, and both involve the same regional rail technology with automatic fare collection and one-person train operation, like PATCO's Lindenwold line. The two alternatives do differ, however, in terms of extent of layout. This difference is the result of differing assumptions about regional land use and development. Therefore, it is necessary to consider land use patterns, trends and alternative futures in order to properly appreciate the two rail development proposals.

Alternative I, also referred to as the Modernized System, presumes a general continuation of existing land use and demographic trends. However, Alternative II, the Expanded System, is predicated on a pattern of concentrated development in and around major transit nodes. The two systems carry with them, as integral parts, different development futures for the region. It is helpful, then, to turn briefly to the issue of land use and transportation development, to better understand just how the two alternatives fit into the region's future.

2.1.1 Development Scenarios

In one of its more theoretical land use reports (Policies and Scenarios for the Delaware Valley), the Delaware Valley Regional Planning Commission sketches out ten regional land use scenarios and discusses each briefly. In coming up with the scenarios, the Commission chose to consider variations in regional growth rates (moderate, slow and no growth), and in areas of development (dispersal, urban fringe and in existing centers). Although the report's discussions of growth rates are not particularly enlightening for the immediate purposes at hand, the different possible growth areas present the transportation planner with food for thought. The report is singularly lacking in discussion of the transportation system, but the implications may be easily drawn.

As noted above,DVRPC's report sets forth three possible general locations of development: regionwide dispersal, on the urban fringe, and in existing centers. The report is less clear on this point, but the development itself can either be scattered across the growing area, or concentrated around specified points.

Putting these factors together, one gets a series of land use futures on both the macro and micro scales. Given a description of land use patterns at both levels, it becomes possible to talk about the transportation system necessary to serve each land use development scenario. Figure 2-1 shows such a range of possibilities and briefly sets forth their implications for the transportation system.

Figure 2-1

General Implications of Development Scenarios

Location of Development:	Nature of Development: Scattered over growth area	Nature of Development: Concentrated around designated points
Dispersed beyond presently developed areas	Increased low-density development served only by automobile. Continued decline of mass transit.	New centers beyond urbanized area. Increased pressure on both highway and mass transit networks.
Urban Fringe	Increased low-density development served only by automobile. Mass transit steady at best.	New and strengthened centers at edge of urbanized area. Both road and transit networks under pressure.
Existing Centers	Redevelopment of existing areas at varying densities. Some revival of mass transit.	Redevelopment of declining centers. Some increase in automobile travel; shot in the arm for mass transit.

Clearly some of the combinations are more likely than others. Scattered development is most likely to occur at the urban fringe or beyond, and concentrated development is most likely to happen in existing centers. However, it is clear which scenarios support the automobile and which support mass transit as the preferred transportation mode. Transit performs well when development is concentrated in existing centers and/or around specific nodes; otherwise the transit system continues to decline and automobile use grows. Alternative I, the Modernized System, will not perform well unless at least one of these conditions are met. Alternative II, the Expanded System, requires an even more conscious policy choice in favor of concentration of growth both in existing centers and around specific nodes.

2.1.2 Land Use--Transportation Combinations

There seems to be very little written on the transportation implications of different land use patterns in the Philadelphia region. Fortunately, there is practical literature on the subject in other regions. Toronto's *Transportation Alternatives: A Summary* does a very good job of integrating these two normally disjointed issues. This report proposes a series of seven transportation and land use combinations (in addition to a "do-nothing" alternative), from which the Toronto region is asked to choose.

For each of seven land use scenarios, the planners selected the most effective transportation system to serve it. Interestingly, four of the land use options share the same transit-oriented transportation system, with rail transit lines serving circumferential as well as radial trips. One of the alternatives with this transportation system, "Subcentre Development," is selected along with "Central Area Concentration" and "Metro Dispersion" as being the most likely. According to the report, "the subcentre concept is the one which from a transportation viewpoint, may be the most desirable, but it is also the one which would require the most definite actions . . . to ensure the emergence of the subregional centres."[1] It should be noted that there is a striking resemblance between Toronto's "Subcentre Development" and the Delaware Valley's "Multi-purpose Centers," as explained below in Section 2.2.1.

Figure 2-2, based on a similar chart in the Toronto report,[2] suggests a range of five land use possibilities for the Delaware Valley, and briefly describes the transportation systems which would best serve the region under circumstances.

As in Toronto, some of the scenarios are more likely than others, given present trends. At the moment, the Delaware Valley region seems to be following the "Decentralization" pattern, whereby functions not required to be in Center City tend to be scattered over a large area. The construction of the Center City Commuter Connection is an effort to strengthen the "Centralization--Center City" model. Much of the debate over the future of Philadelphia on the regional level is implicitly between these two land use alternatives alone, and other possibilities are seldom even

Figure 2-2

Land Use--Transportation Possibilities for for the Delaware Valley Region

Type of Development:	Description	Transportation Needs
Centralization-Center City	Continued dependence on Center City for office functions	Radial network of rail transit and expressways. More circumferential highways needed for outer areas.
Centralization-Center City and King of Prussia	Center City remains strong, while suburban growth directed to King of Prussia	Much the same as above, but new highways and transit lines needed to serve King of Prussia
Multi-purpose Centers	Several Multi-purpose Centers developed into office and commercial centers	Good rail transit to link Multi-purpose Cities with each other as well as Center City
Decentralization	New growth dispersed over a broad geographical area. Extrapolation of present tendancies	Good transit needed to Center City, but elsewhere highway improvements on a large scale
Corridor	New growth channeled along City Line corridor	Good rail transit along City Line, with connections to Center City and rest of region

voiced,let alone seriously considered.

In spite of the extremely limited field of reference within which land use issues are presently being discussed, there are in fact other options available to the region. One possibility is to develop the suburban growth area of

King of Prussia into a major regional center, providing the transportation improvements necessary to bring large numbers of people there and back. This is shown in Figure 2-2 as "Centralization--Center City and King of Prussia." A variation on this theme is corridor development, which might involve intense development along City Line (between Philadelphia and Montgomery County).

The most extreme variation from the present situation is shown in Figure 2-2 as "Multi-purpose Centers" development. In this alternative, office, commercial and residential development would be concentrated around several designated centers. These centers would be linked both with Center City and with each other by an attractive, efficient mass transit system.

If the region is to enjoy the proper functioning of the land use system it chooses, it must correspondingly select a transportation network suited to the task at hand. For the "Decentralization" option, massive highway improvements will be required to facilitate the flow of automobile traffic. For commuters to and from Center City, good transit will still be required because of the sheer impossibility of handling all of Center City's travel needs with the automobile. However, the transit system will not be called upon to handle other types of trips on a large scale. For the "Corridor" option, perhaps the least likely of all the scenarios, new rail transit will be needed along the City Line corridor, and perhaps between City Line and Center City as well.

Both "Centralization" options are quite well served by the study team's proposed Alternative I, the Modernized System. Alternative I has the effect of making both Center City and King of Prussia more easily reached from much of the region than is presently the case. To a lesser degree, the local centers would benefit from increased accessibility to Center City and from station joint development.

The "Multi-purpose Centers" option is excellently matched with the proposed Alternative II, the Expanded System. The various local centers will be much more easily reached by transit, not only from Center City but also from each other. This increased accessibility will allow these centers to draw from a broader market, while yet paradoxically reducing some of today's unnecessary travel by allowing people to live closer to their jobs.

It is clear that both Alternatives I and II (and especially the latter) call for better coordination between land use and transportation than is presently occurring in the Delaware Valley. This type of coordinated planning has been carried out for some time in Europe and Canada, but has not yet become common in the U.S. The study group is convinced that it is crucial to building an attractive urban environment in the Delaware Valley and other American metropolitan areas.

There is no question here of making abstract plans of marginal value to the region. On the contrary, the city and suburbs alike have a practical and pressing interest in bringing these various land use and transportation issues into the realm of public debate. Despite the many city-suburban bones of contention, both parties have a long-term interest in seeing to it that the region as a whole is considered an attractive place to live and work, and the proposed Alternatives I and II will do a good deal to help the Delaware Valley's competitive position.

It may seem that there is not necessarily a need for such a regional revival. However, the fact that the area's competitors--New York, Washington, Baltimore--also have major problems does not in any way alleviate those of the Delaware Valley. The region's attention is diverted from its own serious metropolitan problems merely because none of its rivals have dealt adequately with their problems, either. The same can be said of other regions vis-a-vis the Delaware Valley and its problems.

However, the example of Toronto and Buffalo demonstrates that once a metropolis breaks out of its complacent mold, it can significantly improve its competitive advantage. Before the 1950's, Toronto was such an uninteresting metropolis that its inhabitants regularly sought weekend escape in Buffalo. Then in the 1950's and 1960's, Toronto handled major growth in a manner quite different from contemporary U.S. practice. The area got a metropolitan government, whose unified tax base has facilitated land use and transportation decisions benefitting the entire region rather than only the city or the suburbs. It is the policy in Toronto to encourage concentrated development around rail transit stations. Such is Toronto's confidence in joint transportation - land use planning that a four-mile automated rail transit line is being built to link a subway terminal with a newly-developed suburban center. With Toronto's pro-transit emphasis and coordinated planning, 25 percent of all trips within the Metropolitan boundaries are by mass transit.[3] And Toronto's pleasant urban environment attracts tourists from all over, including many weekend visitors from Buffalo.

The Delaware Valley's transportation and land use revolution will not be a carbon copy of Toronto's, much though the northeastern U.S. can benefit from south-central Ontario's experience. In keeping with the setting and the times, this region will use whatever tools are at hand, with its own distinctive style. However this region formulates and implements a new land use-transportation policy, it will be necessary to promote high-density development near rail stations. This is a necessary precondition for the long-term success of both systems, especially Alternative II. If the Delaware Valley's rail system is to be truly revived, it is not enough to deal with its technological obsolescence alone. The service operates on an obsolete network, which must itself be brought up to date. Once this is done, the regional rail network will provide the Delaware Valley's residents with an enviably high level of mobility, and help out in the adventure of creating an urbane and inviting metropolitan environment.

2.2 Regional Land Use

by Carmen Blassini

2.2.1 Regional Development Plan: Multi-purpose Centers Concept

The regional development plan for the Delaware Valley specifies three different levels of urban centers. These centers represent concentrations of residential, commercial and industrial activity throughout the region, and have been defined in terms of the area which they serve. There are three main categories: Metropolitan Center, Regional Centers and Sub-regional Centers.

Several locations in the Delaware Valley Region provide a variety of commercial, cultural, recreational, governmental, industrial and residential activities, which are criteria for their consideration as multi-purpose centers. These areas are easily recognized, being distinguished from the surrounding area by the intensity of development and the mix of activities.

The multi-purpose centers concept is a key issue in the development plan for the Delaware Valley Region. These centers provide the focus for existing adjacent communities, as well as other surrounding communities. The intensity of development that they offer makes it possible to provide public services, such as water, sewers and public transportation more cheaply than if the same activities were spread out, causing diseconomies of scale. On the other hand, the distribution of goods and other non-public services will be facilitated since they are concentrated in one place, making it more convenient to the individual consumer as well as to the providers.

In general terms, a system of multi-purpose centers effectively linked with each other and with Center City Philadelphia is the essence of the regional land use plan, and as such, is intended to achieve more organized growth and development for the entire region.

2.2.2 Categories of Urban Centers and Criteria for their Selection

Approximately forty-four core areas were selected as multi-purpose centers in the five-county study area (Philadelphia, Delaware, Montgomery, Chester, and Bucks Counties). The location and distribution of these areas were based on an analysis of 1980 Census data showing municipal growth patterns for the 1970-1980 period; the land use development patterns for the same period[4] which show land use changes for single-family, multi-family and commercial/institutional/industrial uses within each municipality; and finally, the projected population and employment for the year 2000.

Major attention was also given to the Delaware Valley Regional Planning Commission's recommendations for the location of these expected growth areas, since their selection is based on population pressure for suburban expansion, existing large residential development, large scale industrial and commercial investments, and significant improvements of the infrastructure, especially highways and sewer facilities.

As mentioned before, there are three main categories of urban centers according to the area they serve. These categories are defined in Figure 2-3. The first is the Philadelphia Central Business District (CBD), which is the region's Metropolitan Center. The second category--Regional Centers--are distributed throughout the rest of the counties and are represented by six major Urban Centers: Chester City, Media, West Chester, Norristown, Pottstown and Doylestown. The third and last category is defined as Sub-regional Centers, which constitute important nodes of activity and are represented by thirty-six urban centers or major development areas of the region.

2.2.2.1 First Category: The Metropolitan Center. The Philadelphia Central Business District has been clearly defined as the major focus of activity for the entire Delaware Valley Region. It has the largest concentration of employment in the study area, and provides a wide range of commercial facilities, major financial institutions, highly specialized retail shops, regional offices for the federal and state governments and nationally important health and cultural institutions. In terms of transit facilities, Center

Figure 2-3

System of Multi-Purpose Centers

County	Category of Center		
	Metropolitan	Regional	Sub-Regional
Philadelphia	Philadelphia CBD		-North-east Philadelphia Airport -Cottman-Bustleton- -Germantown -North Broad -Kensington-Allegheny -City Line -University City -South Philadelphia
Montgomery		Norristown Pottstown	-Lansdale -King of Prussia -Ardmore -Fort Washington -Jenkintown -Abington -Willow Grove -Plymouth Meeting -City Line -Cheltenham
Delaware		Chester City Media	-Granite Run -Springfield -69th Street -Wayne
Chester		West Chester	-Paoli -Phoenixville -Exton -Downington -Coatesville
Bucks		Doylestown	-Oxford Valley -Neshaminy -Bristol -Tullytown -Langhorne -Morrisville -Warminster -Sellersville -Perkasie -Quakertown

City Philadelphia is the focal point of one of the nation's most extensive commuter rail and transit systems.

The Philadelphia CBD is expected to experience long-term growth in certain economic sectors such as business services (finance, insurance, real estate) and governmental activities. However, certain areas of the economy, such as retail and manufacturing have declined and moved to either shopping malls in growing suburban areas or out of the region.

In general terms, it can be said that the Philadelphia CBD has a unique function in the Delaware Valley Region. As the Metropolitan Center, it serves the entire region as well as adjacent portions of other states.

2.2.2.2 Second Category: Regional Centers. Six Regional Centers have been identified in four of the region's Pennsylvania counties: Media and West Chester City in Delaware County, Norristown and Pottstown in Montgomery County, West Chester in Chester County, and Doylestown in Bucks County. This category comprises centers serving an entire county or a major portion of a county. The centers involved are usually the central business districts of older cities, and include most of the county seats. Chester City and Pottstown are the only centers which are not county seats; however, they are large, older communities which serve large portions of their respective counties as employment and service centers.

Regional Centers are generally defined as service areas providing different types of activities such as specialized retailing, wholesaling, large-scale banking and office functions, government, health, cultural facilities, containing residential and industrial activities as well.

2.2.2.3 Third Category: Sub-regional Centers. Thirty-six sub-regional centers have been identified throughout the five Pennsylvania Counties. This category of centers is defined differently according to various types of development in the region. For instance, it is possible to find old business districts of communities which have been important in the region's growth history. An example of this type of center is Quakertown in Bucks County. This center was built up around older production facilities and acts as a service area to the surrounding communities.

Another type of sub-regional center is the shopping mall. These developments are large clusters of stores on a single site, with their own circulation systems, parking, and amenities. Many examples of this type of development can be found in the region; among the most important is the King of Prussia shopping mall--one of the largest retail centers in the nation--located in Montgomery County. Other major shopping malls in the region are Willow Grove, Granite Run, Springfield, Oxford Valley Mall and Neshaminy Mall. This particular type of development was a major consequence of the advent of the automobile; therefore these large clusters of stores are usually surrounded by huge parking lots, which are usually filled up during certain periods of the year such as Christmastime. Although these shopping malls are now largely dependent on the automobile, it is expected that with a major improvement in transit facilities allowing direct access, many shoppers will switch from the automobile to an improved, reliable rail transit system.

Another type of sub-regional center development is linear strip development. These areas have developed along commercial and business activity corridors, and have a high traffic volume. A good example of this type of development is City Line, located along the boundary of Philadelphia and Montgomery Counties.

In general terms, many of the centers identified here represent activities which are distributed over a larger area including several types of development in combination. The selection of these activity nodes tries to reinforce concentrated development, which will result in economies of scale for the region's entire population.

2.2.3 Relationship between the Multipurpose Centers and the Regional Rail System

The existing commuter railroad system provides access to all the regional centers identified above through lines radiating from Center City Philadelphia. This radial system also connects several sub-regional centers with each other, such as Jenkintown-Fort Washington-Lansdale, Willow Grove-Warminster, North Broad-Bristol-Tullytown and Ardmore-Wayne-Paoli. Center City Philadelphia is highly accessible from all the major activity nodes in the region, but on the other hand transit service in the suburban areas is limited to connections between the metropolitan center and the regional center of the county where they are located.

The two regional rail alternatives are based on an effort to combine land use planning--in this case the multipurpose centers proposal--with transportation planning. The first alternative--the Modernized System--strengthens the relationship between the Metropolitan Center and the different Regional Centers, as well as serving a major growth area at King of Prussia. This alternative is aimed at reinforcing five Regional Centers: Chester City, Media, Norristown, Doylestown and Trenton, providing a frequent, reliable transit service of lines radiating from Center City Philadelphia. The Modernized System also involves a short circumferential line connecting highly travelled corridors at two major centers in the region: Norristown and Fort Washington.

The second alternative--the Expanded System--promotes stronger links between the different regional and sub-regional centers. This system not only provides transit service to and from the Philadelphia CBD, but also interconnects other parts of the region through a circumferential line. Basically, this alternative tries to link up important regional and sub-regional centers with each other, as well as serving future development areas along the way. The circumferential line provides an alternative to those riders travelling to and from Regional and Sub-regional Centers, reducing the congestion in Center City Philadelphia. Four major centers are directly linked together by this line: Chester City, West Chester, Norristown and Trenton. Besides these centers, there are also important traffic generators served directly or indirectly, including King of Prussia, Plymouth Meeting, Neshaminy Mall, Langhorne and Oxford Valley Mall (see Figure 2-4).

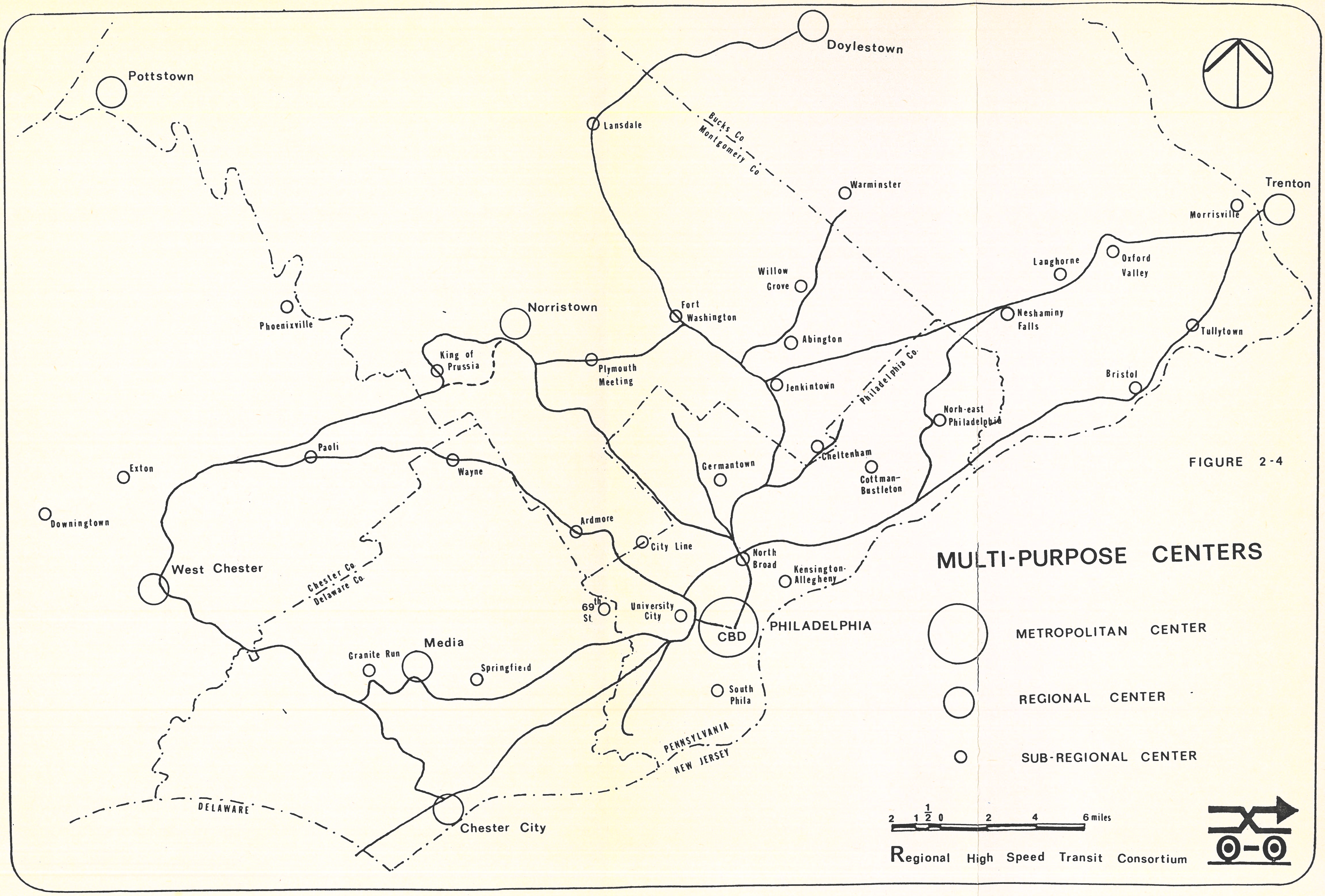


FIGURE 2-4

MULTI-PURPOSE CENTERS

2.3 The Multi-purpose Center as a Development Alternative

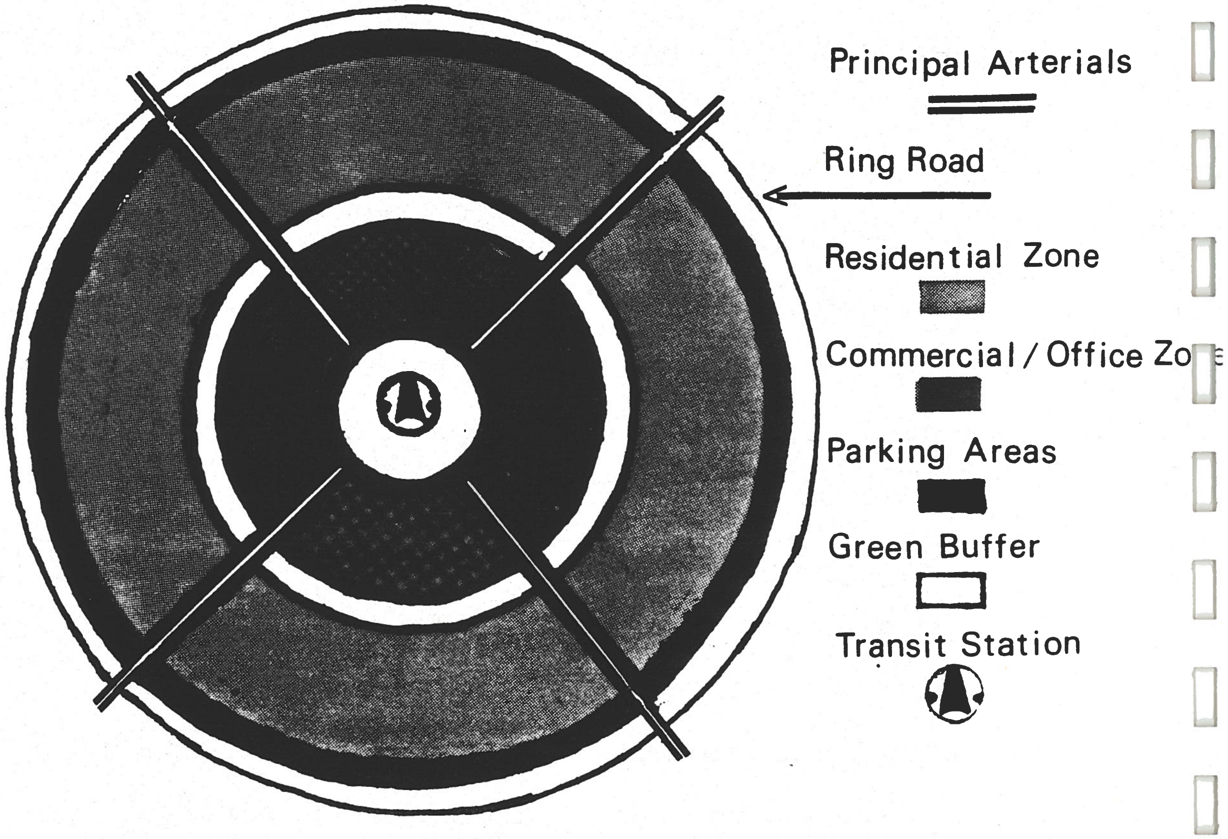
by Scott Gibbons

Despite the considerable movement toward more dense settlement, information in the Delaware Valley indicates that the economic and amenity pressures for suburban development are as strong as ever. Suburban pressure is due to two factors in particular: lower cost per square foot of land and housing, and lower density (hence more space and greenery) than areas around a typical node. Since the multi-purpose centers are themselves nodes, efforts must be made to mitigate these disadvantages. Increased transit accessibility alone is not enough of a positive incentive for residential location; the areas other amenities must be improved as well.

Figure 2-5 shows a sketch development for a prototypical multi-purpose center. Briefly stated, it provides for limited areas of vehicle access into a traffic circle around the transit station. This circle is surrounded by a circular commercial and office development zone. No residential development is permitted in this zone in order to prevent the development of a hierarchy of housing rents based on proximity to transit stations. Instead, there is another circle where only high-density residential development is to be permitted. The advantage is that it surrounds the commercial and office zone with nearly equal access to

Figure 2-5

Prototypical Mini City Land Use Plan



that zone from anywhere in the residential zone. Because it surrounds the inner zone, it should provide access to the node while making rents low enough to encourage some suburbanites to move there. If coupled with a green, wooded buffer between the two zones, the open space amenities of the suburbs could be combined with the benefits of a central location (as Pei has done in his Society Hill Towers design).

REFERENCES--CHAPTER 2

[1] Metro Toronto Planning Department, Transportation Alternatives: A Summary, circa 1975, p. 22.

[2] Ibid., p. 11.

[3] Metro Toronto Planning Department, What Kind of City? A Profile of Metropolitan Toronto, June 1974, p. 16.

[4] DVRPC, Development in the Delaware Valley 1970-1980, September 1982.

BIBLIOGRAPHY--CHAPTER 2

Delaware County Planning Department. Delaware County Land Use Plan 2000. Philadelphia, 1978.

Delaware Valley Regional Planning Commission. Development in the Delaware Valley, 1970-1980. Philadelphia, September 1982.

Delaware Valley Regional Planning Commission. Final 1980 Census Counts Showing Municipal Growth Patterns. Philadelphia, October 1982.

Delaware Valley Regional Planning Commission. Goals and Objectives for Regional Development. Philadelphia, 1982.

Delaware Valley Regional Planning Commission. Policies and Scenarios for the Delaware Valley, Year 2000 Report #2. Philadelphia, 1977.

Delaware Valley Regional PlanningCommission. Regional Development Guide for the Delaware Valley. Philadelphia, 1982.

Delaware Valley Regional Planning Commission. Year 2000, Report No. 4, Alternative Futures for the Delaware Valley. Philadelphia, 1976.

Gruen, Victor. The Heart of Our Cities. Simon and Schuster, New York, 1964.

Hall, Peter. The World Cities. McGraw-Hill, New York, 1966.

Metropolitan Toronto Planning Department. Metroplan: Concept & Objectives: A Summary. Toronto, 1976.

Metropolitan Toronto Planning Department. Transportation Alternatives: A Summary. Toronto, h.s. (circa 1975).

Montgomery County Planning Commission. Land Use Plan. 1977.

CHAPTER 3

ALIGNMENT AND TECHNOLOGY OF ALTERNATIVE I AND ALTERNATIVE II

by Aurelio Menendez and John Allen

3.1 Alignments

by Aurelio Menendez

3.1.1 Introduction

The Philadelphia commuter rail system is one of the largest in the nation, but it has major problems. It is an expensive system and serves only limited segments of the metropolitan region and its people's travel needs.

The system operates twelve different lines and consists of two major networks--the Philadelphia and the Reading districts--which up to now have been operated separately. The rail system plays a crucial role in moving people between downtown Philadelphia and outlying suburban residential areas. Clearly, the region already has a major capital investment in the rail system. This is being further augmented by the $340 million for the Center City Commuter Connection tunnel, which will connect both divisions, and another $100 million on the new line to the airport.

If one adds to this such issues of regional concern as changing population trends, the energy crisis, the need for increased mobility, and the area's environment, one can easily see the potentially important role that a modern regional rail system can play. An efficient, economical, modern, high speed, high capacity, regional rail transit system holds great promise for meeting many regional objectives.

Efficient transit network design is an important prerequisite of good service and economical operation. This chapter recommends two alternative alignments for just such a rail system, and furthermore discusses the methodology which has been followed in the selection process, and the goals and objectives to be achieved with each specific alternative.

The primary purpose of the selection of an alignment is to provide rail service in those corridors where there is existing and/or potential future demand for it. There are important limitations to the area that the existing system covers, while in a few cases service is provided to areas that do not need it now nor are expected to in the future. This chapter will identify these problem areas while recommending new alignments where they are needed, and the elimination of some existing ones that are not needed.

The goals to be achieved through the selection of the specific alignments may be summarized as follows:

- To enhance the accessibility of major traffic generators in the region.

- To provide an attractive alternative to the automobile through an improved high speed mass transit system.
- To develop a system which responds to the heaviest current and projected future travel demand.
- To develop a system which will significantly reduce the financial burden of operating subsidies on local governments.
- To design a system which will preserve the environment and conserve energy.

Considering all these aspects, two major alternatives have been developed. One, called the Modernized System (Alternative I), is a more reserved approach which tries to provide highly improved service to areas which now need it and to those with potential future for growth, given the region's existing socioeconomic trends. Another one, called the Expanded System (Alternative II), is a more bold approach which is based on existing and future urban centers and subcenters. Indeed, in some respects the Expanded System is a logical outgrowth of the Modernized System, but it also results from improved coordination of transportation and land use policies.

In order to preserve the environment and to keep the investment costs as low as possible, both alternatives have been developed with an effort to make the best possible use of the area's existing passenger rail network, freight-only lines, and even abandoned rail rights-of-way.

3.1.2 Methodology

Once the goals and objectives for the system are established, the next step in the process of selecting alignments is to determine the criteria to be considered for accepting or rejecting a possible alignment.

The criteria selected for justifying the provision of rail service in a particular corridor include six major items:

- The expectation of a future minimum ridership level compatible with the technology being considered.
- Future growth potential (residential, commercial, or industrial).
- Insofar as possible, consistency with county and regional plans for the year 2000.
- Availability of right-of-way, adequate physical conditions (topography, geology, etc.), and land use opportunities along any new proposed alignment.
- Compatibility with other rail operations (Amtrak, Conrail freight) in the proposed alignments where other rail service is being operated on existing tracks.
- Other aspects such as socio-economic characteristics, political factors, and so on.

Figure 3-1 shows data on the performance, productivity and efficiency of the existing lines. These items are of major importance in evaluating the current operation of existing lines.

Applying these criteria to each alternative accomplishes a preliminary evaluation of the two alternatives. The results allow the selection of an optimum alignment in terms of the stated criteria. Next, an optimum technology is recommended for each alternative.

The probable future ridership in each corridor was also computed from total trip figures, and an estimate was made of potential ridership for each technology within a corridor. It was assumed that a light rail system would be able to attract up to 6 percent of the total home-based work trips in a corridor, a rapid transit system up to 10 percent, a modern commuter rail system up to 15 percent, and a regional rail system up to 22 percent. These percentages come from current figures from rail systems in various North American cities.

3.1.3 Alternative I: Modernized System

Alternative I is based on an extension of the present demographic and socio-economic trends to the year 2000. Within this framework, the system strengthens those lines with good ridership potential and discontinues service on those with low projected future ridership. New alignments

Figure 3-1

Present System Ridership by Line

Line	Revenue/ Expense Ratio (1981)	Passenger Miles/ Car Miles (1981)	Passenger Miles/ Crew Miles (1981)	Weekday Passengers (May 1982)	% Change of Weekday Passengers since May 1981
Fox Chase	0.65	1.43	25.09	2,644	- 4.4
Chestnut Hill West	0.62	2.52	44.35	4,436	19.3
Paoli	0.56	2.01	41.52	9,259	-16.7
Media/ West Chester	0.56	2.40	39.46	6,627	-21.0
Warminster	0.54	1.26	24.54	3,008	-17.9
Trenton	0.53	1.14	34.03	3,584	-16.4
Chestnut Hill East	0.53	2.09	26.37	2,315	-23.5
Lansdale	0.51	1.13	19.09	2,471	+51.0
Doylestown		0.98	21.02	1,439	-43.7
West Trenton	0.45	0.76	19.85	2,782	- 8.2
Wilmington	0.40	1.57	35.32	4,497	- 7.8
Norristown	0.31	1.08	12.26	1,221	-12.7
Manayunk	0.27	2.04	19.59	682	-18.4

Source: Delaware Valley Regional Planning Commission, Commuter Rail Contingency Plans: Alternative Mobility Options for the Delaware Valley, Final Report, Orth-Rodgers and Associates, Inc., December 1981.

have been proposed only in those corridors with a high demand for rail transit and readily available right-of-way.

According to these guidelines, two new alignments are proposed for Alternative I in addition to the Airport line which will be connecting Penn Center, 30th Street Station, the Civic Center and the Philadelphia International Airport.

The first new alignment would link Norristown to King of Prussia. Rail service could be provided on an existing industrial spur which would need to be upgraded, double tracked and extended to the shopping mall, using Conrail's North Abrams Industrial Track as far as the First Avenue grade crossing. Alternatively (thinking of Alternative I as a first stage to Alternative II), service could be provided to a station south of the mall on the Reading's Chester Valley Branch, requiring a new bridge connection south of Norristown with the existing Reading main line.

The second new alignment connects Fort Washington, Plymouth Meeting, Norristown and King-of-Prussia Plaza. The line would use an existing freight right-of-way along the Penn Central's Trenton Cutoff from its intersection with Reading's Norristown line to its intersection with the Reading main line to Lansdale, where a connection would need to be built. Alternative I envisions a northbound connection to the existing station at Fort Washington. By contrast, Alternative II would require a southbound connection in order to facilitate the creation of a circumferential line, so whatever decision is made would be of major regional importance. The Penn Central Trenton Cutoff alignment would require the construction of an electrified double track line paralleling the existing freight trackage.

In summary, the recommended alignments and technologies for Alternative I are as follows (see Figure 3-2):

i. Retain as is, but progressively convert to regional rail (Lindenwold Line type of service):

- South Corridor:
  - Wilmington line to Marcus Hook
- Southwest Corridor:
  - West Chester line to Elwyn (one stop beyond Media)
- West Corridor:
  - Paoli line
  - Norristown line to King of Prussia (using new alignment described above)
- North Corridor:
  - Chestnut Hill West line
  - Lansdale and Doylestown lines
  - Warminster line
- Northeast Corridor:
  - Trenton line

ii. Retain commuter rail service but with major physical and operational improvements:

- Fox Chase line in the Northeast corridor

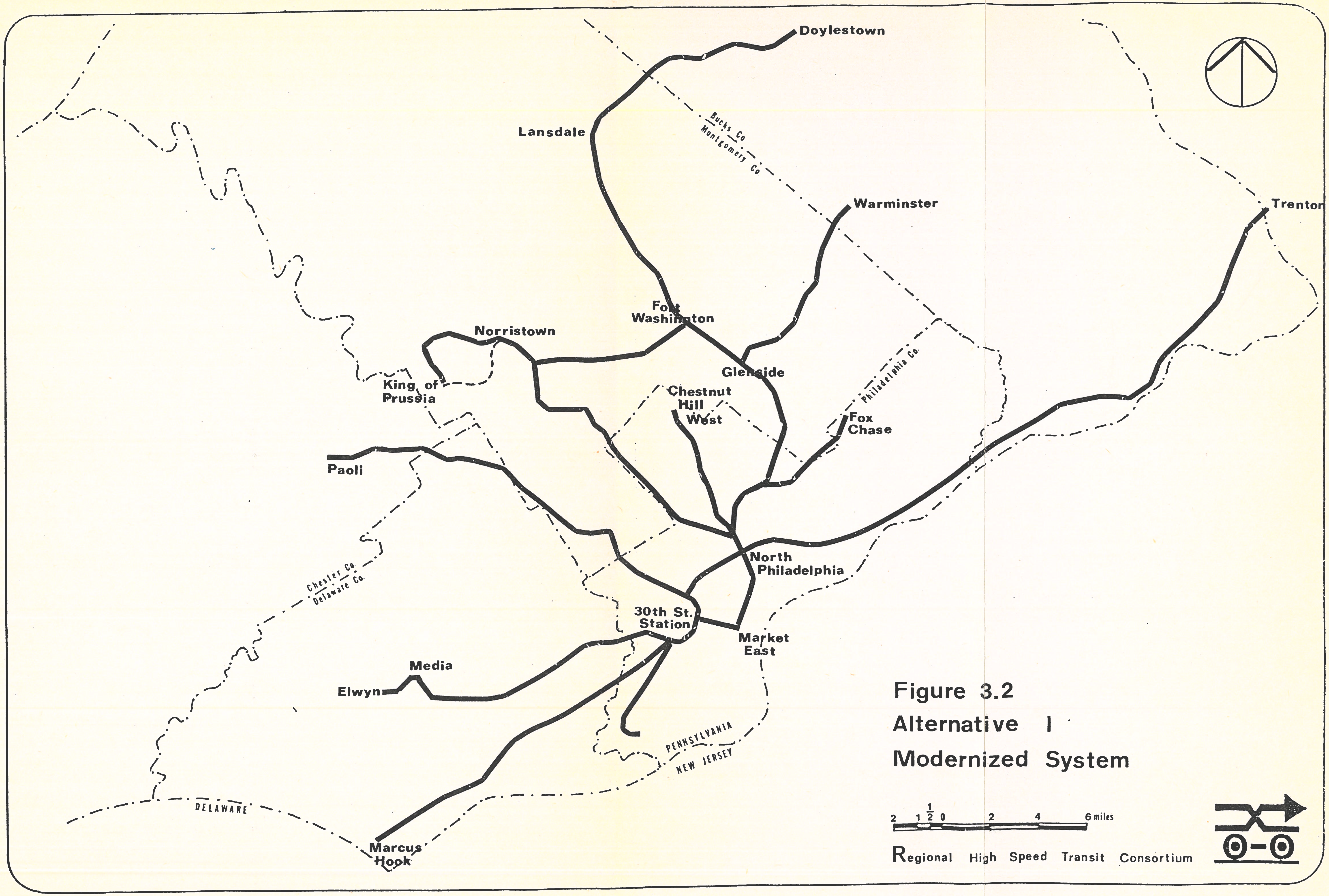


Figure 3.2
Alternative I
Modernized System

Regional High Speed Transit Consortium

iii. Discontinue over long term, although with the possibility of light rail service if warranted:

- Chestnut Hill East line
- West Trenton line as far as Woodbourne

iv. Discontinue over short term:

- West Chester line from Elwyn to West Chester
- West Trenton line between Woodbourne and West Trenton

v. Discontinue immediately:

- Manayunk line

vi. No service, but acquire or retain right-of-way for potential future service:

- Reading line between Norristown and Pottstown
- Reading line between Fox Chase and Newtown

vii. New service:

- Airport line in the Southwest corridor to be operated as a commuter rail service.
- Extension of Norristown commuter line to King of Prussia Mall.
- Circumferential line from Fort Washington to King of Prussia, to be operated as a regional rail line.

All the changes in the lines to be operated under Alternative I would be implemented sequentially. In the first stage, the whole system would be maintained as a commuter rail system but with major operational improvements. In the second stage, a regional rail system would be implemented on all the lines except the Airport and Fox Chase lines. In the final stage, the new alignments would be brought into service.

3.1.4 Alternative II: Expanded System

Alternative II assumes, based on experience in other North American cities, that a modern regional rail system with a high level of service, covering most of the Delaware Valley region would increase ridership sharply. In the long term, it would also promote increased use of the transit system rather than the highway network for the region's development. An expected ridership estimate for such a system would be a multiple of present day ridership on the present system, estimated around 350,000 passengers per day.

This expanded system seeks to serve not only the needs of Center City Philadelphia, but also to connect other regional centers so that they will be served directly or indirectly, eliminating the present need to go through Center City. In fact, Alternative II makes a special effort to serve sub-regional centers all along the way.

Alternative II retains all of Alternative I's lines with small modifications, and adds major new lines, most of them circumferential, linking the most important residential, commercial, and industrial centers of the area. In doing so, not only are absolute values of ridership expected to increase, but also the percentage of non-work trips would increase, resulting in higher rail transit ridership, producing even more travel on the system, and enhancing the region's quality of life and attractiveness.

The differences from Alternative I (Modernized System) are as follows:

a) Extension of the Media line to Lenni via Granite Run Mall. A new alignment would be constructed between Media and Glen Riddle stations going north up to US-1. This alignment would provide convenient access to Granite Run Mall, an important regional commercial center. The alignment follows the topography in order to avoid steep grades, as shown in Figure 3-3. The existence of the Riddle Memorial Hospital near the Mall will require very careful design and proper landscaping along the track in order to avoid noise pollution which could hurt the health facility.

b) Extension of the Paoli line to Frazer. This alignment already exists and is a part of the Philadelphia-Harrisburg line.

c) New circumferential line. This new alignment would begin at Chester on the Marcus Hook (Wilmington) line. The alignment would use the existing Penn Central track up Chester Creek from Chester to Lenni. This section of the line would need to be electrified, upgraded and double-tracked. Beyond Lenni to West Chester, the alignment would use the

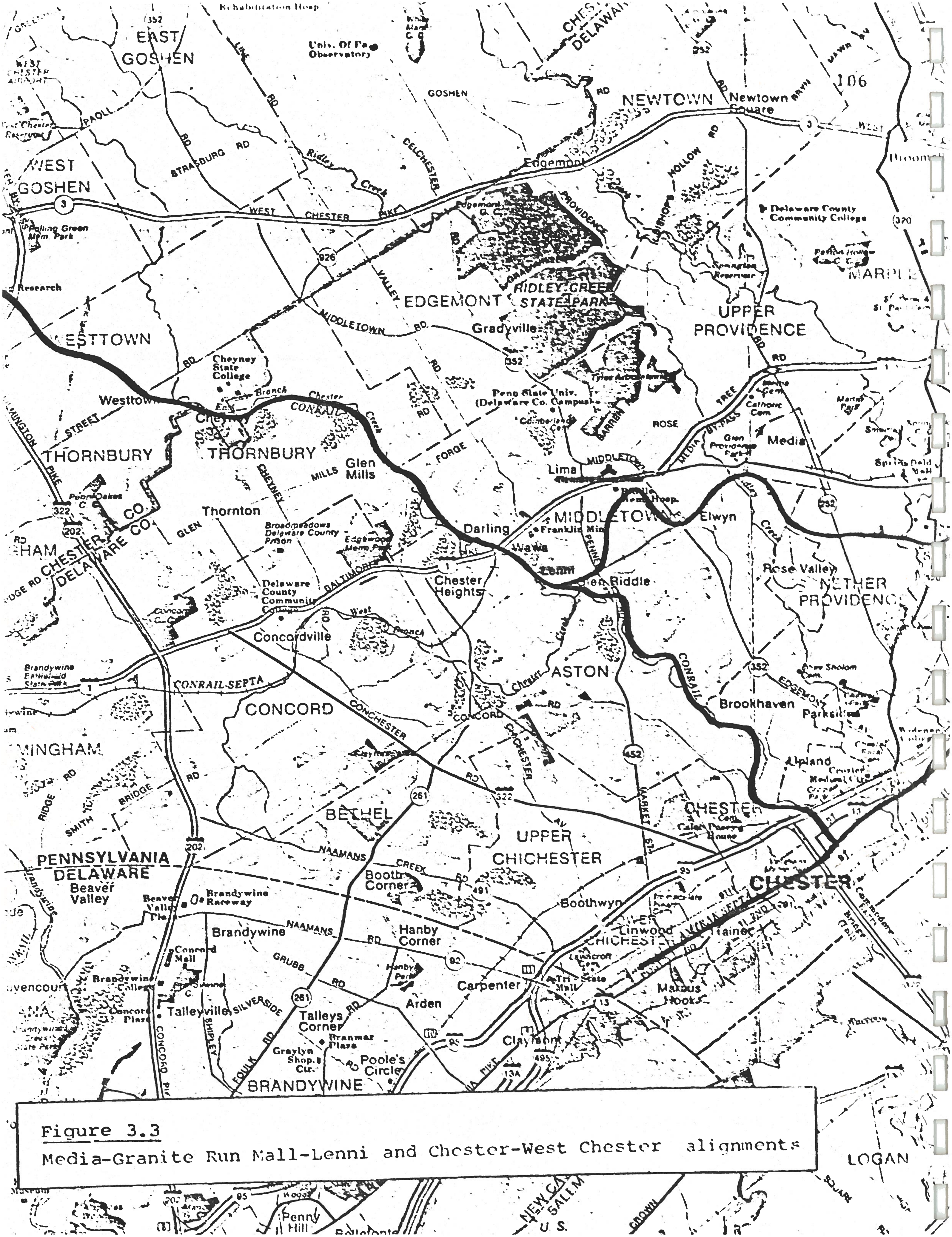


Figure 3.3

Media-Granite Run Mall-Lenni and Chester-West Chester alignments present West Chester line. This section would need to be upgraded and double-tracked. With these arrangements, Lenni would have to be converted to a transfer station to allow easy connections between the Media-Granite Run Mall line and the circumferential line. A preliminary design for this station is shown in Figure 3-4.

Beyond West Chester, the circumferential line follows the abandoned Penn Central line to Frazer. The abandoned railroad right-of-way has track remaining in place. It is interrupted in two places by new highways, but the highways and the former rail line are at different levels. New track can be built at grade at relatively low cost. Like Lenni, Frazer would be a transfer station, this time between the Paoli and the circumferential lines.

From Frazer the circumferential alignment would go to the King of Prussia Mall. Two new alignments, of about one mile each, would have to be constructed. The first, immediately after Frazer, would connect the Paoli line to the Penn Central Trenton Cutoff. Approximately three and a half miles further on, the second alignment would link the Trenton Cutoff to the Reading Chester Valley Branch which parallels it to the north (see Figure 3-5). With this layout, the circumferential line would go as close as possible to the King of Prussia Mall and would cover areas with major future growth and ridership potential.

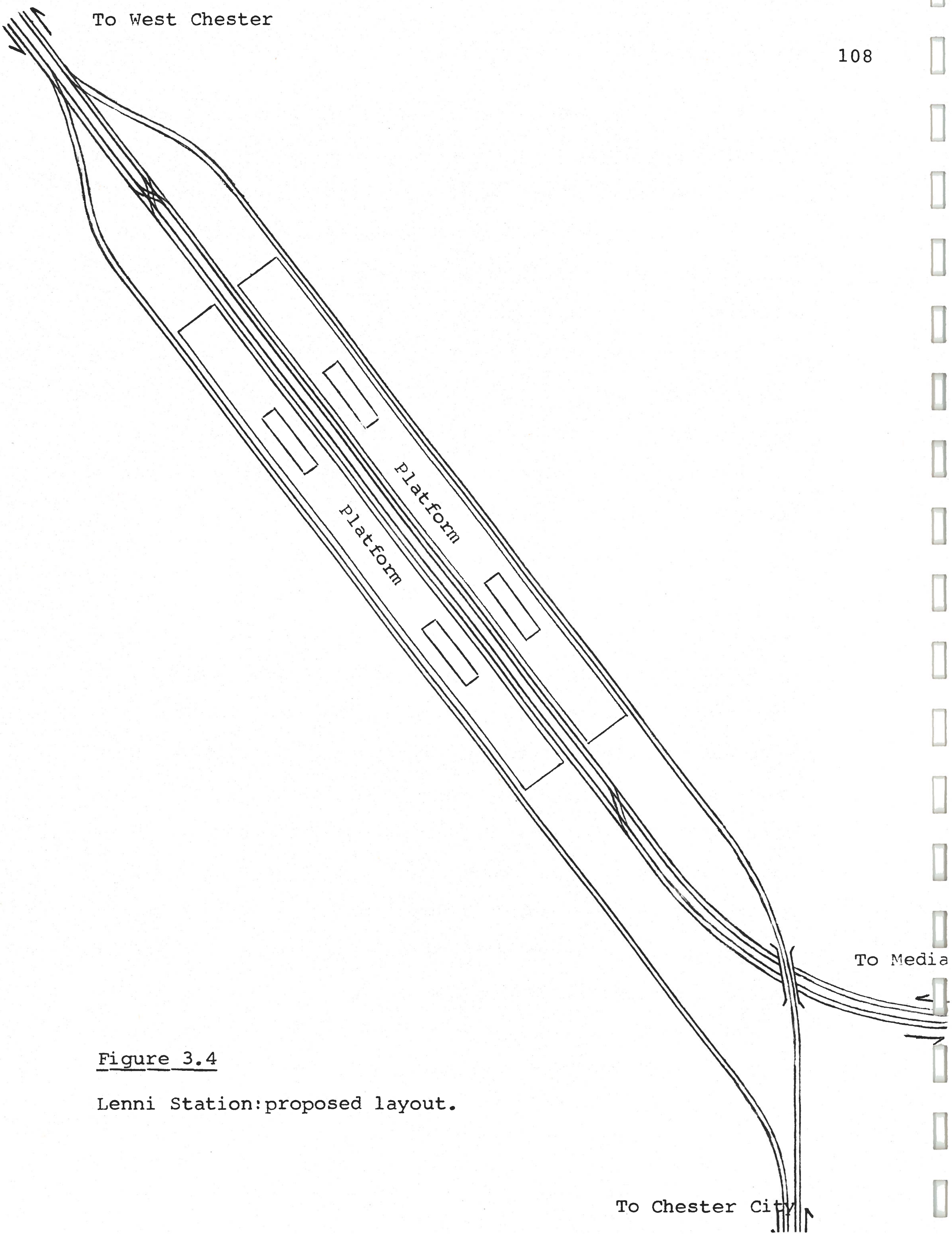


Figure 3.4

Lenni Station: proposed layout.

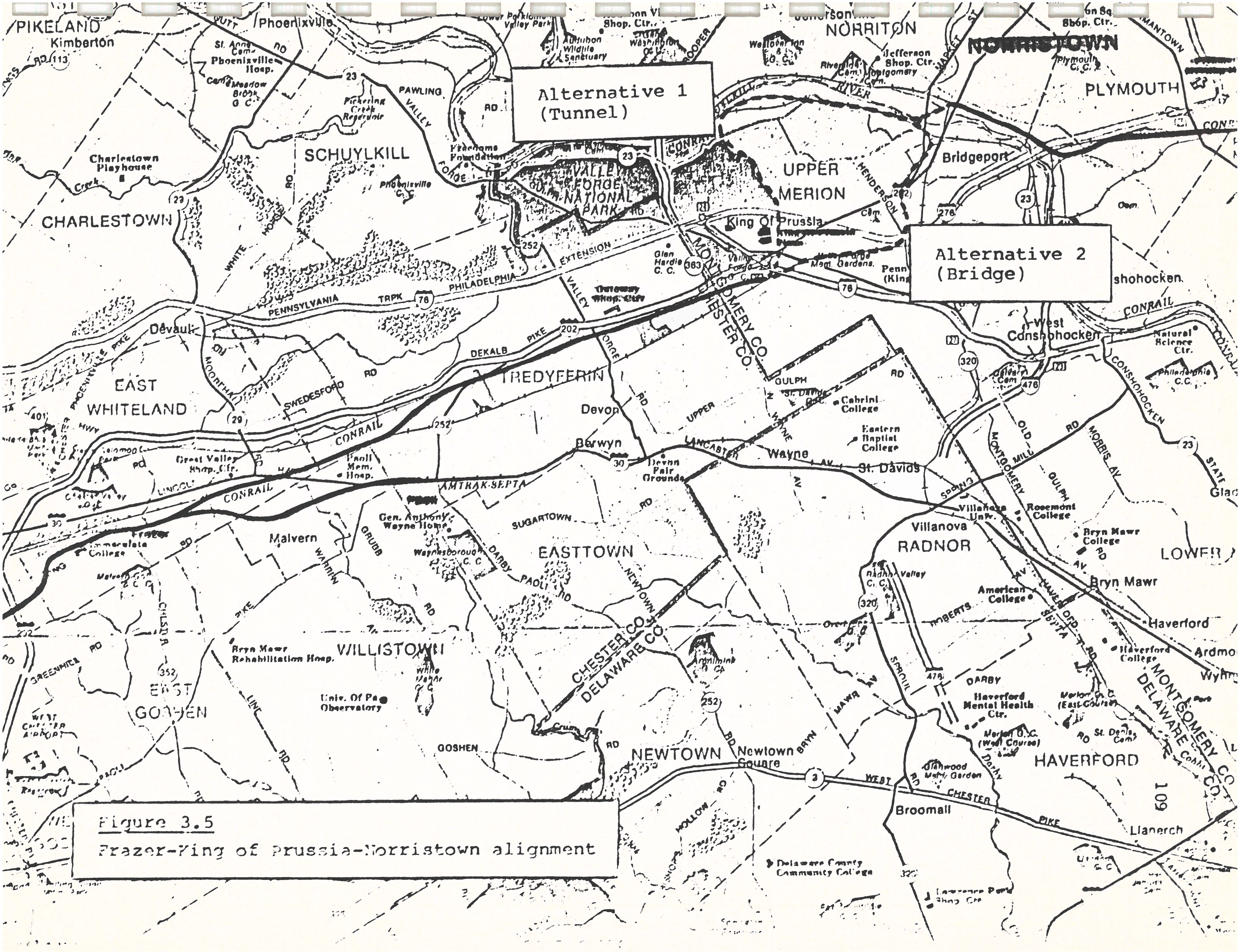


Figure 3.5
Frazer-King of Prussia-Norristown alignment

At this point two alternatives are possible. One would continue the line on the Reading Chester Valley Branch to Bridgeport and north to Norristown DeKalb Street Station, crossing the Schuylkill River at Barbadoes Island. This crossing would require the construction of a new bridge from the southern side of the river to the island to connect with the Reading main line. This alternative would preclude the first alignment proposed in Alternative I between Norristown and King of Prussia. It would require a people-mover system between the mall and the station, which would be located south of DeKalb Pike (PA-202). On the other hand, the second alternative would maintain the alignment from Alternative I but would require the rather expensive construction of a tunnel under the Plaza to connect the Reading line to the North Abrams Industrial Track. A more detailed cost-benefit analysis is needed, considering the attractiveness of an underground station at the King of Prussia Mall and the expense involved. However, such an analysis falls beyond the scope of this study.

From Norristown, the circumferential line would follow the proposed Fort Washington-Plymouth Meeting-Norristown alignment of Alternative I, turning south instead of north to Fort Washington station as considered in Alternative I. A new station, called Keystone, should be built at this important intersection, which is also a major highway interchange of the Pennsylvania Turnpike (I-276) and Fort

Washington Expressway (PA-309). From Keystone the circumferential line goes on to the Lansdale line inbound to Glenside continuing eastbound on the West Trenton line to Woodbourne from the junction just north of Jenkintown. In this section either a realignment should be made at Neshaminy Falls station to bring the rail line closer to Neshaminy Mall, or a people-mover should be built to the Mall. The existence of Route 1 between the railroad and the Mall makes the task of building a direct rail connection rather difficult. Perhaps a local transfer system, administered by the mall management could solve this problem.

A few feet before Woodbourne station, the alignment would rejoin the Trenton Cutoff to Morrisville where the circumferential line would connect with the Trenton line. At the junction of the West Trenton line with the Trenton Cutoff, convenient access can be easily provided to the Oxford Valley Mall by bringing the tracks closer to the Mall.

d) Greater Northeast Philadelphia line. This line would be part of the Trenton line as far as Holmesburg Junction. After this station the alignment goes diagonally across the Far Northeast on Conrail's Bustleton Track, a freight line, as far as an industrial track which goes to the airport. The alignment would go to Roosevelt Boulevard, continuing on industrial tracks which would need to be upgraded and double tracked. At this point the track would parallel the Boulevard on a separated right-of-way as far as the U.S. Treasury building. Just before the building, the alignment would cross the Boulevard and take another industrial right-of-way to connect with the New York Short line (see figure 3-6). Since Roosevelt Boulevard is a major thoroughfare, it would be necessary to build a bridge to take the rail over it. Once on the New York Short line, the alignment would continue to Neshaminy Mall where this line would connect with the circumferential line at a transfer station.

This alignment would provide convenient access to the Far Northeast, which , aside from the eastern and western fringe areas, has little rail service. This line would also provide connections to the Northeast Philadelphia Airport, the Northeast Shopping Center, the Philadelphia Industrial Park, Pennypack Park, and Neshaminy Mall.

e) Finally, three more alignments were analyzed, but it was decided that they are of a considerably lower priority. Their implementation would be worthwhile only over a very long period of time.

The first of these three alignments would link Lansdale to the Lower Bucks area, and the Far Northeast. The difficulty in this case is that the line would require the construction of approximately 13-1/3 miles of completely new right-of-way.

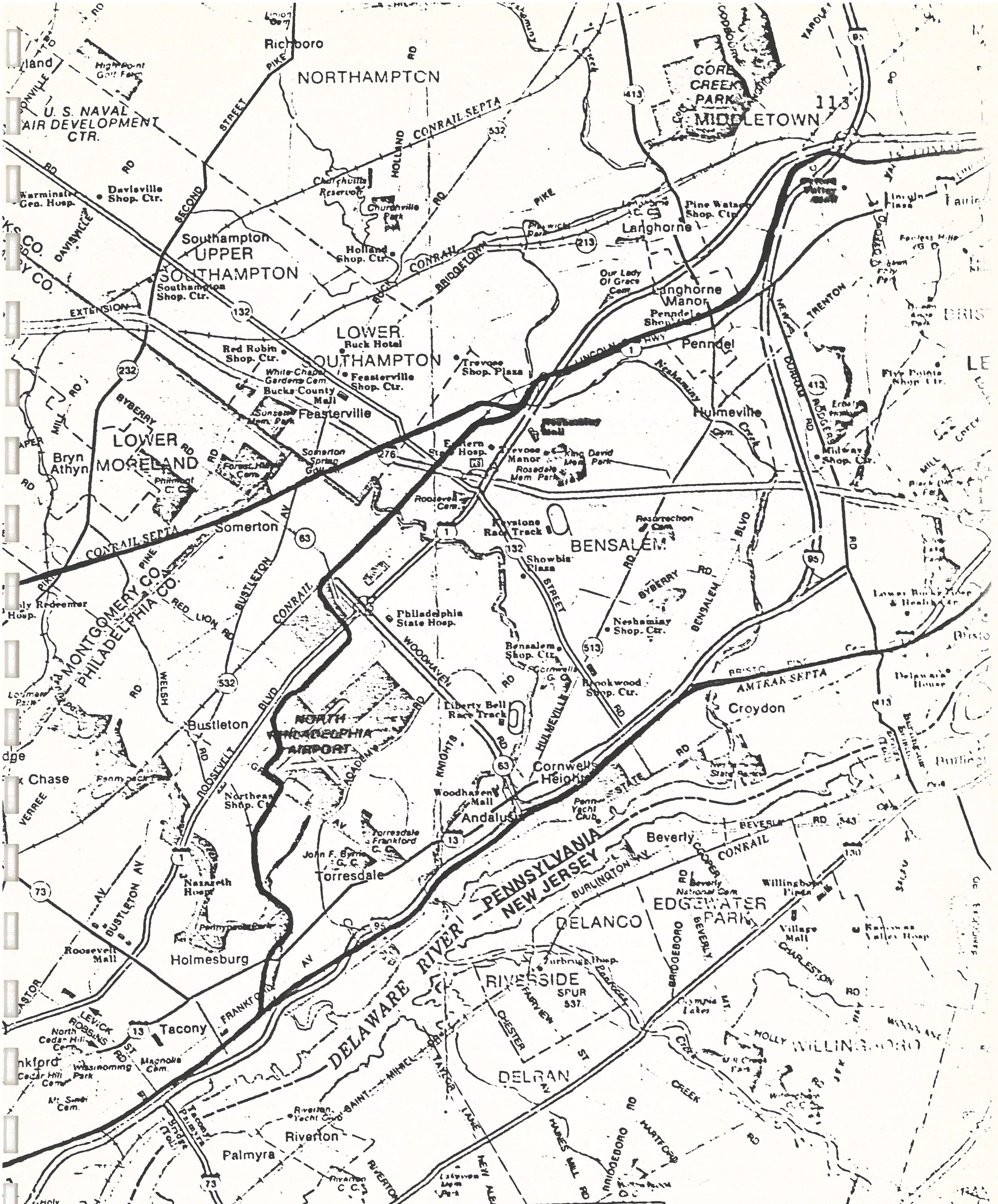


Figure 3.6

Holmesburg-Neshaminy-Oxford Valley Mall alignment

The second alignment is the existing line between Norristown and Pottstown, and the third would be a new alignment connecting the City Line area and the Norristown line. Both can now be considered to be of low priority. But if regional policy was to develop either of these corridors intensively, it would be necessary to bring these lines into service sooner.

In summary, the recommended alignments and technology for Alternative II are as follows (see Figure 3-7):

(i) Regional rail lines:

- South Corridor:
  - Wilmington line to Marcus Hook
- Southwest Corridor:
  - West Chester line to Lenni
- West Corridor:
  - Paoli line to Frazer
  - Norristown line to King of Prussia
- North Corridor:
  - Chestnut Hill West line
  - Lansdale and Doylestown lines
  - Warminster line
- Northeast Corridor:
  - Trenton line
  - Greater Northeast line, from Holmesburg Junction to Oxford Valley Mall (via Philadelphia Northeast Airport)

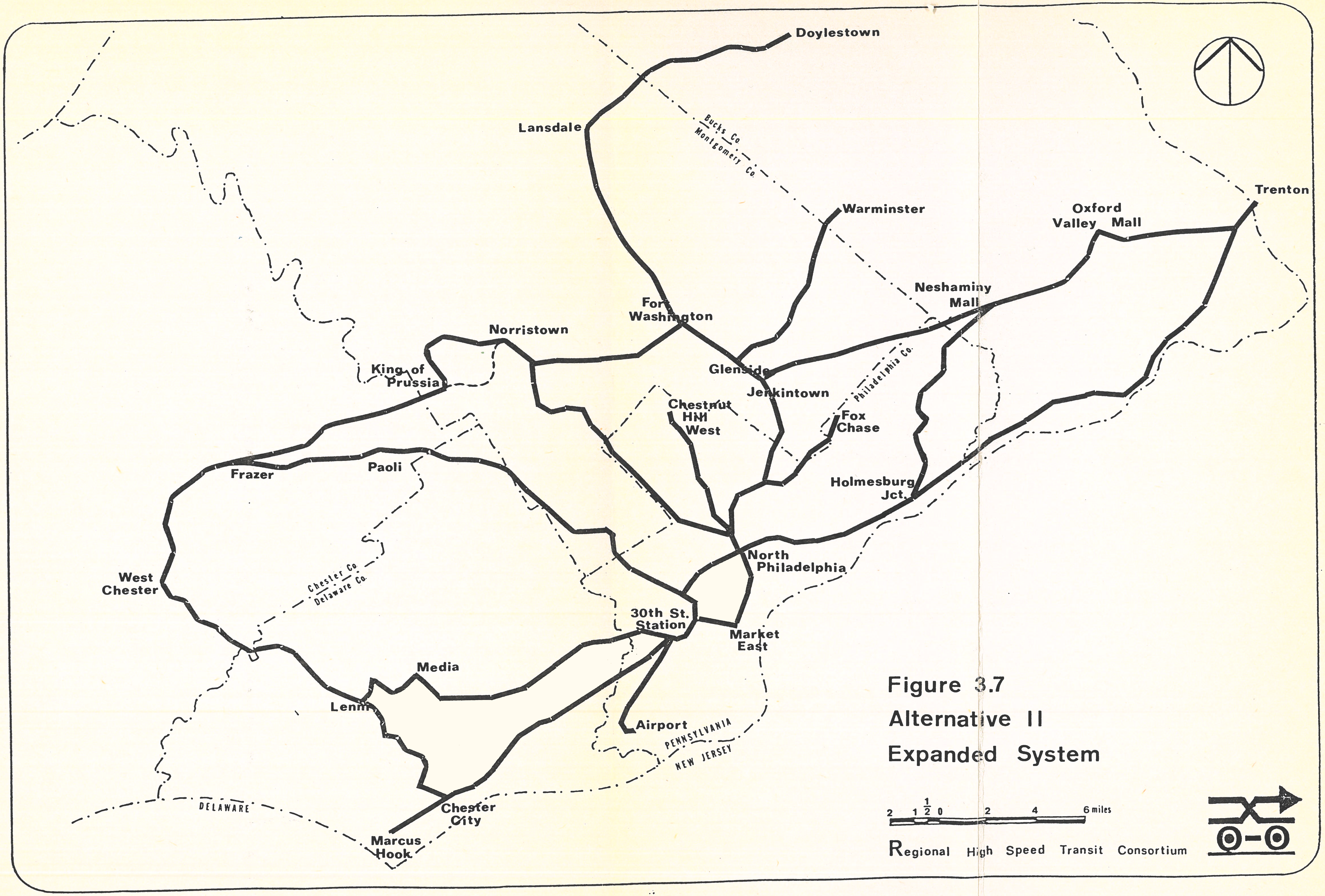


Figure 3.7
Alternative II
Expanded System

Regional High Speed Transit Consortium

- Circumferential Corridor:
  - Circumferential line linking Chester City, Lenni, West Chester, Frazer, King of Prussia Mall, Norristown, Plymouth Meeting, Glenside, Jenkintown, Neshaminy Mall, Oxford Valley Mall, and Trenton.

(ii) Commuter rail lines:

- Northeast Corridor:
  - Fox Chase line to Fox Chase
- South Corridor:
  - Airport line.

3.2 Technology

by John Allen

This section of the report attempts to describe the specific technological requirements of the recommended systems. The following paragraphs will help clarify what is required to transform the existing commuter rail system into a modern regional rail network.

A note about terminology: Throughout the report, reference is made to "commuter rail" operating on certain lines, whereas "regional rail" is projected on most lines. As envisioned, the difference is not in terms of technology (which will conform to similar standards throughout) but merely in terms of service frequencies. Therefore, this section will describe requirements which are equally applicable to commuter and regional rail.

The section covers station design, fare collection, rolling stock, track and power, and signalling and communications, in that order. As both the Modernized and Expanded Systems have the same technological characteristics, this section covers both alternatives equally.

The study group chose the regional rail technology, based on information supplied by the technology work group. Appendix I summarizes this information. Also, the study group selected the fare collection technology based on another technology work group memo, reproduced in Appendix II.

3.2.1 Station Design

For the most part, especially with Alternative I, the Modernized System, the regional rail trains will be serving existing commuter rail stations. Therefore, it is desirable to use existing station facilities in both alternatives wherever possible, in order to minimize new investment costs. However, there are two problems with existing commuter stations which render them questionably suited for regional rail service in their present condition. One is that most of them have low level platforms; the other is that all of them now permit unrestricted platform access to riders and non-riders alike. It will be helpful to deal with the first problem before moving on to the second.

Currently, there are very few stations equipped with high level platforms, as noted above in Chapter 2, section 2.2. Meanwhile, riders at some of the system's busiest stations today must climb up and down the trains' steep vestibule steps in order to board and alight. This situation needlessly delays trains at their stops and inconveniences passengers.

High level platforms need to be built in both alternatives studied at all stations where service is to be retained. Based on the experience of the Long Island and Metro-North systems in New York, it should be quite feasible to construct the high level platforms directly on the site of the low level boarding areas. As a result, most of the stations will continue to have lateral platforms.

At Ardmore and Paoli, Amtrak trains must be kept to the center tracks and regional rail trains will stay on the outside tracks. The outside tracks will need to be slightly relocated in order to make way for new twin high level island platforms. As at Newark, N.J., where PATH and Amtrak-NJ Transit passengers are kept in separate areas, a fence will have to be built along the Ardmore and Paoli platforms separating the metropolitan and intercity travelers. There will be separate access for each system. Amtrak's Harrisburg trains could terminate at the lower level of 30th Street (where there is ample platform capacity) rather than at Penn Center as is now the case.

Access can be provided between the inbound and outbound platforms either by overhead or underground passageways. Underground walkways would be easier for the passengers, but would be more expensive to construct. Where underground passageways are used, they will have to be built to high security standards so as to avoid making the off-peak rider fear walking through them at all. Closed-circuit television monitors and frequent security patrol visits would help. Montreal and Washington have taken major steps to make their underground environments reassure rather than threaten the traveler. Similar provisions should be useful here.

At stations where new track construction is involved, it would be desirable to use a more compact central or island platform design. This would reduce construction costs, and would not add to passenger confusion if clear graphics are used from the start.

Wherever possible, the existing (often substantial) station buildings should continue to be used. They can provide a warm waiting area for rush-hour crowds in the winter, as well as house the ticket machines and fare gates. For outbound platforms (and any stations lacking suitable waiting rooms) waiting shelters must be provided. Chicago has put passenger-activated electric heaters in the ceilings of some of its rapid transit station shelters; these radiate warmth for two or three minutes at the press of a button.

3.2.2 Fare Collection

The regional rail system needs to use automatic revenue collection (ARC) at all stations. The ARC system will be quite similar to that used on PATCO's Lindenwold line, except that certain changes will be necessary to accommodate the more complicated fare structure of the regional rail network.

Fares for both alternatives should be based on distance travelled, with a minimum fare applying for short journeys. Upon entering the station, passengers should be able to find a system map clearly showing all the stations on the system. The highest standards of graphic clarity must be used in designing this map. A "You Are Here" marker should identify the particular station and help travelers orient themselves. A three-digit number code should be shown on the map beside each station's name. To the side of the map, there should be an alphabetical index of all the stations in the system, along with their triple-digit codes and coordinate location on the map. It is of the utmost importance that the maps and indices remain clearly visible and undefaced at all times.

After determining their destination station and its numerical code, passengers should then step to a nearby ticket vending machine. Figure 3-8 shows how the system map and vending machine might actually appear in a station. Passengers should punch in the numerical code for their destination and select the type of ticket desired (rush-hour, off-peak, one way, round trip, or weekly). The vending machine should then display the price of the ticket. It should accept all coins plus one- and five dollar bills, and it should also be able to give change. If not, bill-changing machines should be provided. Monthly Trailpasses could be sold by mail, at Center City stations, and perhaps some major outlying stations where ticket agents might be retained for the purpose.

The numerical codes for the different stations should, insofar as possible, follow a logical order for adjacent

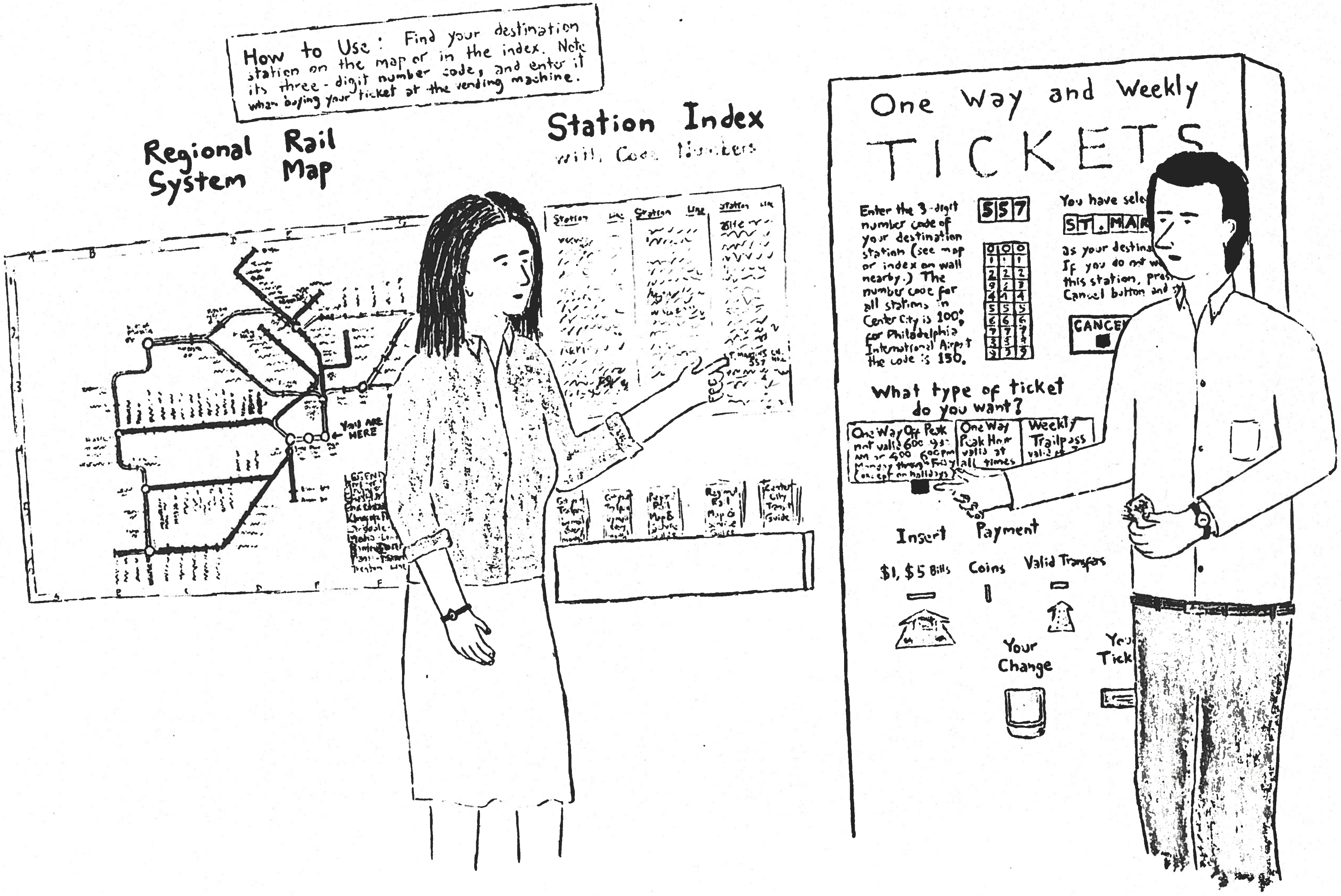

How to Use: Find your destination station on the map or in the index. Note its three-digit number code, and enter it when buying your ticket at the vending machine.
Regional Rail System Map
Station Index
with Code Numbers
YOU ARE HERE
One Way and Weekly
TICKETS
Enter the 3-digit number code of your destination station (see map or index on wall nearby.) The number code for all stations in Center City is 100; for Philadelphia International Airport the code is 150.
557
You have sele
ST. MAR
as your destina
If you do not w
this station, pres
Cancel button and
CANCE
What type of ticket do you want?
One Way Off Peak not valid 6:00-9:00 AM or 4:00-6:00 PM Monday through Friday (except on holidays)
One Way Peak Hour valid at all times
Weekly Trailpass
Insert Payment
$1, $5 Bills
Coins
Valid Transfers
Your Change
You Tick

Figure 3-8 Passengers Buying Tickets

stations on each line, e.g. Overbrook-401, Merion-402, Narberth-403, etc. Major stations, such as those at the regional centers, subcenters and shopping malls, should have easily memorized numbers. The code for Center City should have the most memorable code of all, perhaps 100. Or perhaps a special button could be provided on the vending machine so that Center City-bound travelers need not punch in a code at all, but just push a button marked "Center City." If not, there should be a clear notice on the machine: "Center City code number is 100. For other station codes, please consult map." The code numbers would be written on the tickets along with the station names and ticket type, e.g. "Off-Peak Round Trip, Center City (100)-Overbrook (401).

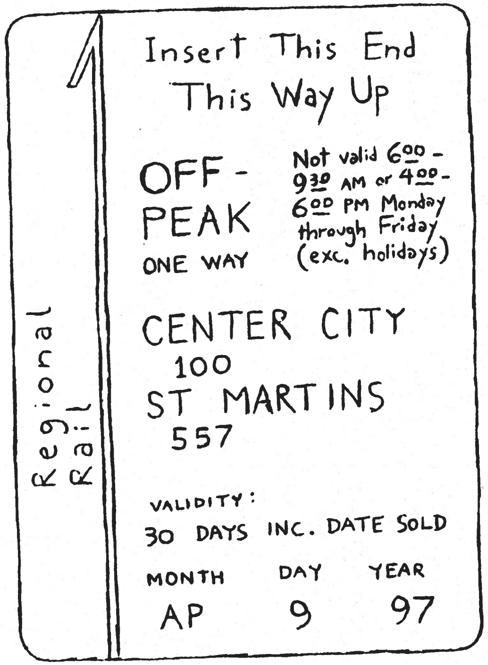
The tickets would be similar to those used on the PATCO and Illinois Central Gulf Electric systems, using magnetic coding on the back of the ticket to store information as to ticket type, time of use, and stations to which it is valid. Given the complexity of the network, it might be just as well to use disposable tickets as the Illinois Central Gulf Electric does in Chicago, rather than attempt recycling of tickets as PATCO does; the sorting and re-encoding of so many diverse ticket types would not be justified by the smaller savings gained through recycling. Figure 3-9 shows an example of a regional rail ticket.

Passengers would pass their tickets through a ticket slot at a turnstile upon entering and leaving the system. The ticket would be checked for validity in terms of station, time and date. Tickets out of validity for any of these reasons (or inserted the wrong way by a passenger overlooking the arrow on the ticket and the "Insert This Way--This Side Up" legend on the ticket) would be rejected. An ARC system designed for British Rail's use on London's commuter rail system provides for a visual display unit informing station staff of the reason for which a ticket is rejected; a similar feature might be good for manned stations on the Philadelphia system. This same London system provides for a four-hour time limit per trip, after which time a ticket is rejected as invalid. Atlanta provides for a twenty-minute interval between turnstile uses of its monthly TransCard to prevent more than one person at a time from riding the rapid transit on the same ticket (unlike the proposed system here, Atlanta uses a flat-fare system requiring fare payment or ticket use only upon entering the system).

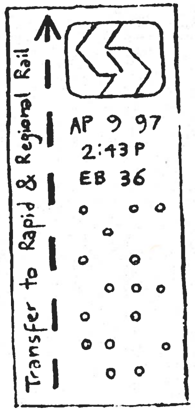
Passengers holding weekly or monthly Trailpasses will be able to use them on connecting bus, rapid transit, and light rail lines. To enhance overall efficient transit use, this same privilege should be granted to occasional as well as regular riders. Passengers traveling towards any regional rail station on any connecting bus, rapid transit or light rail line should be able to purchase for the regular transfer charge, a punch-coded coupon resembling a Montreal transfer (see Figure 3-9). The ticket vendor would accept this coupon (if used within the time limit) at the value of one basic transit fare towards the purchase of a regional rail ticket. The ticket thus sold, however, should carry a clearly-marked warning that unless the passenger enters through the fare gate within ten minutes, the ticket will expire. Rapid transit station turnstiles should also accept these transfers for payment of fare, as in Montreal.

It should not be difficult to provide for transfers from the regional rail system to connecting lines. As Figure 3-9 shows, it should be possible to have the passenger insert the transfer charge into a special slot in the turnstile when entering with a one-way ticket. After recovering the ticket and passing through the turnstile, the passenger should take the transfer from a dispenser, and upon exiting the system, present it for payment of one basic fare on connecting bus, rapid transit and light rail services.

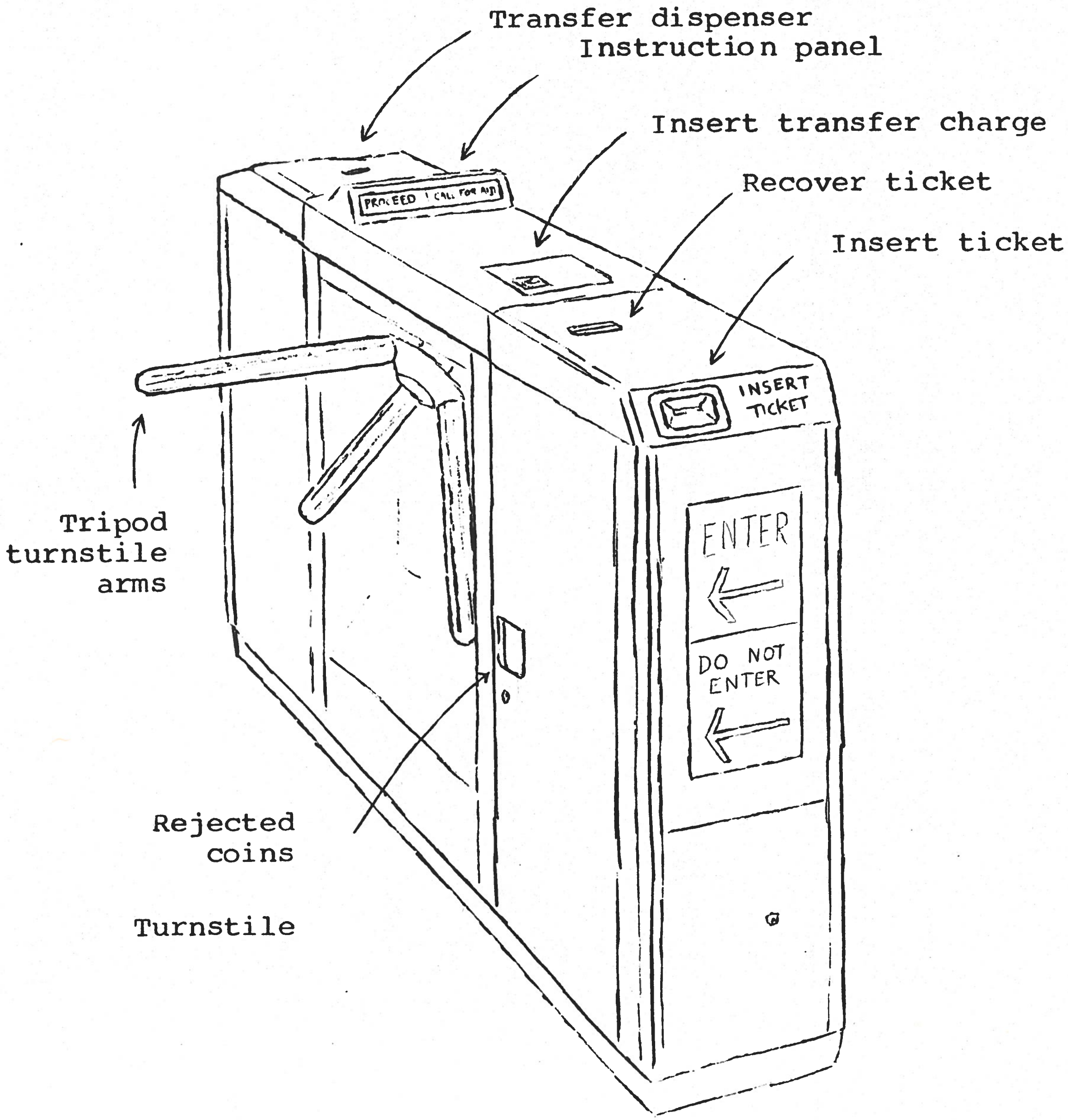
While PATCO's Lindenwold line has no personnel in direct contact with the public, it might be desirable to have attendants at major stations (as BART and the Washington Metro do at all stations) to answer questions, help passengers, and generally provide a reassuring presence. At smaller stations, the attendant's functions would be performed by a call-for-aid phone link, as on the PATCO system.



Regional Rail Ticket


Transfer to Rapid & Regional Rail
AP 9 97
2:43 P
EB 36

Intermodal Transfer



Turnstile

Ticket, Transfer and Turnstile

Ticket agents would be retained (albeit in smaller numbers) at Center City stations and other major points for the purpose of selling monthly Trailpasses. For the convenience of the commuting public, information would be widely diffused on the purchase of Trailpasses by mail.

Excess fares should be handled, as on PATCO, through the "call-for-aid" phones, or by station attendants where these are retained. There should be a special machine at each "call-for-aid" phone into which passengers can insert their tickets so that the staff can verify exactly how much fare has been paid, when the ticket was used, etc. This method is much cheaper than the "Addfare" machines on the Washington Metro and BART.

3.2.3 Rolling Stock

The present rolling stock in use on the existing commuter rail system is only partly adaptable to the needs of a modern regional rail network as envisioned in both alternatives. Provision has been made for the future installation of sliding double doors for high-level boarding on the Silverliner-IV cars, but for the moment all the present commuter fleet must make do with single doors in the vestibules at the ends of the cars. Although both low and high level boarding is possible at these doors, they each have room for only a single passenger. This is hardly adequate door capacity for an 85' mass transit vehicle. The installation of center doors in the Silverliner-IV cars would add another three passenger channels, but even so the front doors would remain out of service in any train because the engineer would need the vestibule for driving.

It might be possible to install central doors in some of the older Silverliner equipment, but this would be more expensive since provision for such doors was not made when the cars were built. Also, since these cars were built about a decade before the Silverliner-IV equipment, such a conversion would be of less long-term benefit to the system. Therefore, it is more likely that the older Silverliners would be sold to other systems, such as NJ Transit, or even demotorized and sold to Boston, which could use more commuter cars.

The Silverliner-IV equipment would need to have the center doors put in, and the appropriate automatic driving apparatus and associated machinery installed. Also, since passenger circulation with the present 3 x 2 seating is very constricted, the triple seats should be replaced with double seats and longitudinal seats should be placed near the doors to maximize standing and walking area for boarding and alighting passengers.

Despite all these modifications, the new system under both alternatives simply requires more cars than are now available in the SEPTA fleet, and these will have to be built to specifications adapted to the system's needs.

Figure 3-10 shows such a proposed car's side, end and interior plans. The new cars should be arranged in semipermanently coupled married pairs. Since excellent performance will be required on gradients of up to 4 percent, all axles will have to be powered. Anticlimbers should be provided on car ends in case of collision, as operations will be much more frequent than they are now.

In speed and smoothness of acceleration and deceleration, as well as in cruising speed, the cars should emulate the performance of the PATCO cars, which accelerate at 3 mphps and cruise at 75 mph. If chopper control of acceleration (which uses silicon-controlled rectifiers to feed electricity to the motors in pulses of increasing length as the train gains speed) seems reliable and economically justified, then by all means the cars should have this feature. If not, it should still be possible to get a very good ride with rheostatic control (dissipating excess electrical energy in the form of heat), as the original Lindenwold Line cars do. More detailed technical studies will be needed to resolve specific issues such as this. In any case, it is important to use proven technology that is known to work.

As with the existing cars, alternating current will be drawn from the wires and converted to direct current before being fed to the motors. This requires more bulky electrical equipment to be carried around than would be needed if

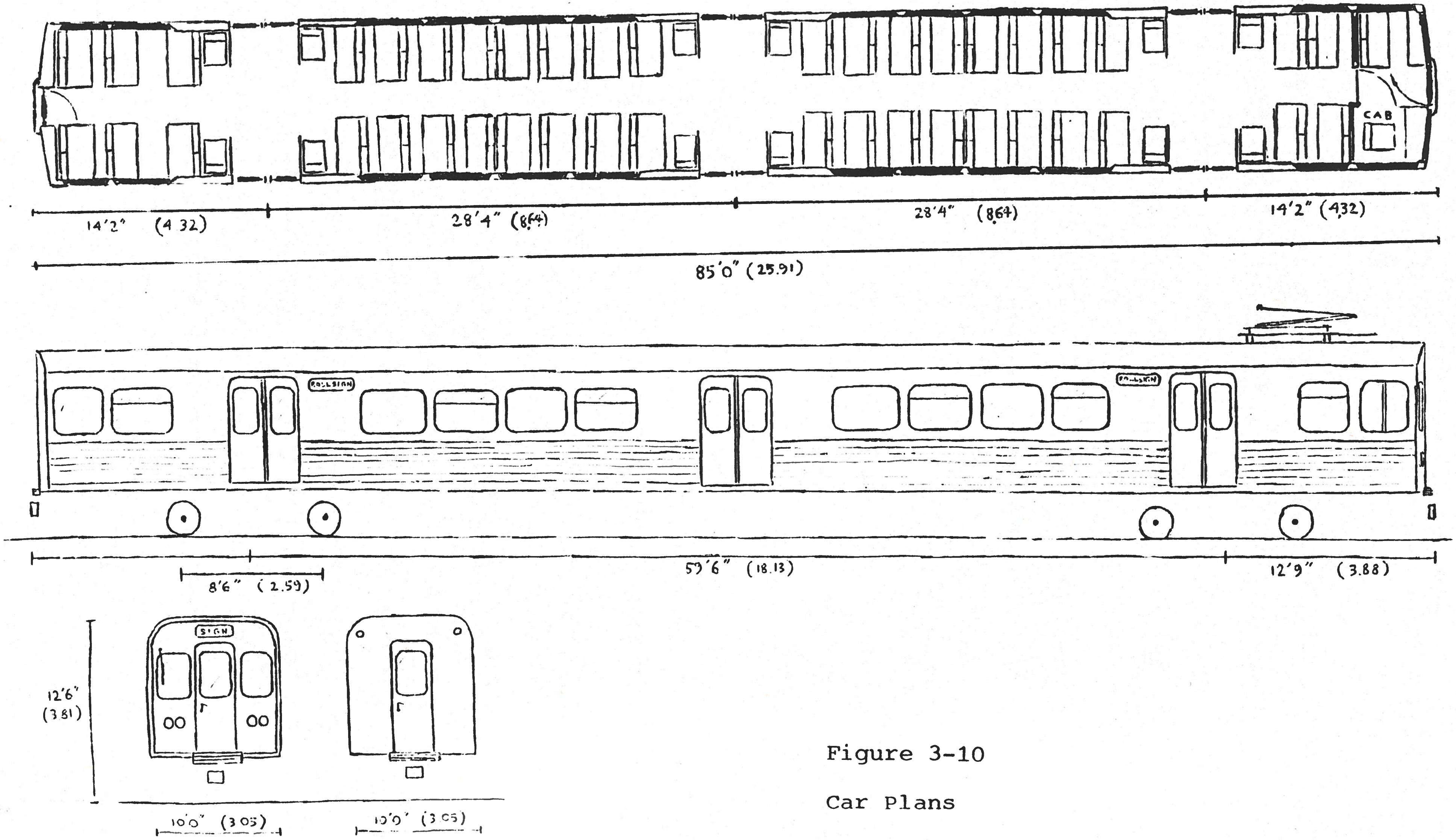


Figure 3-10

Car Plans

the overhead wires were converted to direct current, but that would preclude the operational flexibility of using express tracks on the Amtrak lines, and introduce a number of associated problems such that it would not be worth the effort.

The new equipment should retain the existing cars' dimensions of 85 feet long, 10 feet wide, and 12½ feet high. About 145 passengers could be accommodated on a car, ninety-eight of whom would be seated. Seating should be mostly of a 2 by 2 transverse arrangement with lateral seating near the doors, as shown in Figure 3-10. Unlike with the existing walkover seats on some of the older Silverliners, the new cars' transversal seats should be fixed in direction. Comfort standards should be equivalent to the seats on the Washington Metro, PATCO or the Illinois Central Gulf Electric's Highliners. An interior view of the proposed equipment is shown in Figure 3-11. There should be three double-channel doors per car side; on a car of such length this represents a degree of accessibility somewhere between BART and the Washington Metro.

Since most of the platforms will be on the right hand side, it will help one-person operation to put the driving controls on that side. The enclosed area must measure the full width of the car, so that the train operator can walk over to the left side and operate the doors there when the platform is on that side of the train. When the driving

Regional Rail Map
STOP STANDING IN LINE!
Get your TrailPass by mail instead!
And remember - your TrailPass is also good on all City Transit lines and on all Suburban Division services for the first fare zone!
Regional Rail
Philadelphia Inquirer
Expressway Reconstruction Snarls Traffic
at White House
Joe
SPORTS
SPORTS

compartment is not in use, it should be closed off as on the Washington Metro so that the area is accessible to passengers (except for the cubicle on the right housing the controls). Twin seats for passenger use should be provided on the left side, opposite the controls. These will not be available to passengers while the train attendant is using the compartment, so the seating capacity of the first car of a train will be ninety-six rather than ninety-eight.

3.2.4 Track and Power

Track should continue to be built to standard gauge (4'8½") and must be of such a weight and sturdiness as to accommodate rapid passenger trains. On curves between stations, superelevation should be undertaken so as to raise the top speed at which curves may be rounded in safety and comfort. However, curves should not be superelevated at or near stations; although quite safe it is uncomfortable to stop or go slowly on a superelevated curve. Also, where freight trains are operated caution must be exercised in superelevating curves.

On the present system, the maximum grade outside the commuter tunnel is 2½ percent, and in the new tunnel itself it will be 2.7 percent. The Silverliner can handle grades of up to 3 percent. The only steeper grade is projected for the Expanded System, where a 4 percent grade is envisioned for 2500 feet on the new alignment between Media and

Granite Run Mall. Obviously, it will not be possible to use Silverliners on that particular service.

Amtrak, as the owner of the Northeast Corridor, has plans to convert the Corridor's voltage from the present 11,000 volt 25 hertz A.C. to 25,000 V. 60 Hz. A.C. Fortunately, all the recent cars were designed with this in mind. By the time the regional rail system is in operation, the changeover will probably have taken place. Electrification on the proposed lines will essentially conform to existing standards.

Wherever operations are of regional rail frequency, it is vital to eliminate grade crossings by overpasses or underpasses, when necessary. Besides improving safety, this helps prevent unauthorized people from walking along the tracks near moving trains and from entering or leaving stations in this fashion without paying their proper fare.

Along those few sections where operations are only of commuter rail frequency, it is less imperative to eliminate all remaining grade crossings. However, there should be good surveillance of the platform and track areas to prevent unauthorized entry and exit at stations located near level crossings. A further deterrant to would-be trespassers has been developed in Chicago: long, thin pieces of wood sawn into long strips with sharp triangular edges laid beside and between the rails make it quite difficult to walk along the tracks.

3.2.5 Signalling and Communications

In conformance with standard railroading practice, signals on the present commuter rail network are of an advisory nature only, that is to say that the engineer is not automatically prevented from running a red signal. Since on the existing system headways are never more frequent than 4 mins. 17 seconds per track per hour in one direction on the Penn Central lines and 7½ mins. on the Reading today, there are no major safety problems perceived to be associated with present methods of operation.

However, these methods no longer provide adequate safety standards when operating frequencies reach the high levels projected for the Modernized and Expanded Systems. The signals message must be backed up with an automatic train protection (ATP) system. If the train operator should inadvertently run a red signal while driving manually, an automatic train stop will trip the emergency brakes. The operator will have to break a seal to release the brakes, and the fact that questions will be asked about this later at the yard serves as a strong incentive to the driver to be careful.

These improvements to the signal system can probably for the most part be grafted onto the existing signal block arrangement. However, if this becomes inadequate for some of the busiest sections, e.g. from North Broad Centre to

30th Street, it should be possible to install a moving block system, as has been done on Chicago's elevated lines.

The existing cab signalling system should be retained and probably expanded; certainly it should be provided wherever provision is made for automatic driving. By displaying the signal at all times in the cab, the system allows the operator to know the train's situation regardless of visibility conditions. On some outlying sections, however, there may be no particular need for cab signals to be installed. Indeed, on the Airport and Fox Chase lines, and on the Lansdale-Doylestown section, trains are so infrequent that it may not even be necessary to install automatic train protection (except at the approaches to Arsenal and Newtown Junctions).

The most sophisticated aspect of the proposed system's operations is the automatic train operation (ATO) system. This will only be needed on certain very busy sections between 30th Street and North Broad Centre for the Modernized System (Alternative I), and between 30th Street and the proposed Keystone Station south of Fort Washington for the Expanded System (Alternative II).

It is important to remember that along most of the system, frequencies will not be high enough to justify ATO, so it should not be installed where it is not needed. Montreal's Regional Metro plans call for manual one-man operation throughout the system. Philadelphia would do well to emulate this careful approach. Nevertheless, where ATO is truly needed, it should be provided so that the driver can start up the train at the touch of a button. Provision should be made for manual driving when there is rain, snow or ice, as braking distances are increased under those conditions.

The system should be monitored from a single large control room. Back-lighted boards and TV monitors can provide train controllers with comprehensive overviews and detailed close-ups of operations. On the three Amtrak main lines, it may be necessary to surrender control of the regional rail trains to Amtrak. If so, it is vitally important that there be instant communication available between Amtrak dispatchers and regional rail train controllers. If the two systems' Philadelphia area traffic commands can be located in the same facility, so much the better. Radio telephone communications should put regional rail train controllers within instant reach of all trains.

Several security officers, perhaps in another room, should constantly monitor closed-circuit TV screens giving views from most stations. At the slightest sight of suspicious activity, it should be possible to summon a security patrol on the scene using radio communications.

Back in the train control room, if any service disruption occurs the train controller can pick up a telephone receiver and explain the problem directly to waiting passengers by means of loudspeakers on the station platforms, as Chicago has done. Under normal circumstances, the public address system can also be used to provide music for waiting passengers. The train attendant will routinely announce the stops over a public address system installed in every car, so that passengers need not worry (as they now do all too often) whether they have missed their stop.

BIBLIOGRAPHY--CHAPTER 3

Delaware Valley Association of Railroad Passengers. Year 2000 Rail Transportation System for the Delaware Valley. Paper, April 1979.

Delaware Valley Regional Planning Commission. Commuter Rail Contingency Plans: Alternative Mobility Options for the Delaware Valley, Final Report. Orth-Rodgers and Associates, Inc., December 1981.

Institute of Transportation Engineers. Transportation and Traffic Engineering Handbook, Second Edition. Prentice-Hall, Inc., Englewood Cliffs, New Jersey 1982.

Nelligan, Tom. "SEPTA's Philadelphia: Land of the Silverliners." Passenger Train Journal, February 1980, pp. 33-39.

Pawson, John R. Delaware Valley Rails. John R. Pawson, Willow Grove, PA, 1979.

Pushkarev, Boris S., et al. Urban Rail in America: An Exploration of Criteria for Fixed-Guideway Transit. Indiana University Press, Bloomington, 1982.

Southeastern Pennsylvania Transportation Authority. A Study of the 1975 Railroad System in the Southeastern Pennsylvania Metropolitan Region. SEPACT II Final Report, January 1971.

Tomazinis, A. R. Some Thoughts about the Present Problems and the Future of the Commuter Railroads in the Philadelphia Region. Unpublished Paper, University of Pennsylvania, July 1982.

Transportation Research Board. Report number 760, Philadelphia Center City Commuter Railroad Connection, pp. 8-15.

Vuchic, Vukan R. Urban Public Transportation Systems and Technology. Prentice-Hall, Englewood Cliffs, N.J., 1981.

Visit to installations of PATCO Lindenwold Line, April 1983.

Reports from and conversation with officials of the Conseil des Transports de la Region de Montreal, August 1982 and March 1983.

CHAPTER 4

STATIONS

by Carmen Blassini

4.1 Station Selection Process

The station selection process is based on an analysis of the existing stations' characteristics and the location of major growth areas in the Delaware Valley Region. These two factors were the main criteria used in station selection for both Alternative I and II.

There were three main steps in the station identification process for both systems. The first was an analysis of the existing stations. This involved all the stations on those existing lines recommended for retention, and included such aspects as number of daily trains stopping, number of parking spaces provided (along with an estimate of their use), the predominant land use around the stations, the predominant mode of access (walking, Park & Ride, Kiss & Ride, or bus) and the general quality of the station. It is important to note that not all this information was available for several stations on different lines, since the station surveys by the different planning agencies were limited to specific geographical areas. However, this did not significantly hurt the station analysis process, since it considered the stations as part of an interactive system and not as isolated individual cells.

The second step of the process was an analysis of the stations' passenger movements in order to determine the system's dynamics. This analysis compared 1974 figures with 1982 figures for average daily passenger movements for each station, inbound and outbound. This comparison was very useful for determining station ridership trends. It was also useful in determining each station's share of the line's patronage and ridership concentrations.

The third step of the process was to analyze the proposed land use plan for the Delaware Valley Region. This concentrated on the areas along the existing and proposed alignments, in order to determine the location of major growth areas and potential traffic generators. This analysis was largely based on the location of the proposed multi-purpose centers and their areas of influence.

From the information thus gathered, it was then possible to estimate the potential ridership of the stations in the context of the region's expected growth areas. Taking into account such tehnological considerations as required station spacings, this allowed the elimination of some poorly used stations with little or no growth potential. In addition to this, another criterion for eliminating stations was a station's share of the line's patronage and its proximity to well-patronized stations. Among the stations that were considered for elimination, some showed extremely low daily passenger movements. Typical of this type of station are Baldwin, Trainer, 52nd Street, Ivy Rock, Mogees, Tioga, Nicetown, Frankford and Andalusia, all of which served fewer than ten passengers per day during 1982. Other stations, such as Shawmont, Miquon, Allegheny, Logan, Fellwick, Westmoreland, Highland, Bridesburg, Wissinoming, Eddington, Daylesford, Forest Hills, Williamson School, Eddystone, Lamokin Street, Crestmont and Fulmor accounted for a very low relative share of their lines' patronage. Furthermore, they are not located in the region's expected growth areas. These stations are listed in Figure 4-1.

4.2 Station Upgrading

Most of the system's existing stations should be upgraded to modern regional rail standards. This means high level platforms, automated fare collection and new parking facilities. In respect to the platform level, there are only eight stations in the system that are provided with high-level platforms: the new Market East station under construction, Penn Center, 30th Street, North Philadelphia (Trenton Line platforms only), Westmoreland, Chestnut Hill West, Trenton and Warminster. This means that eighty-three stations on the Modernized System and fifteen stations on the Expanded System will require high level platforms and therefore new shelter facilities or station building redesign as a result.

Figure 4-1

Stations Considered for Elimination
Modernized and Expanded System

Line	Station
Wilmington	Curtis Park Crum Lynne Baldwin Eddystone Lamokin St. Highland Ave. Trainer
Media-West Chester	49th St. Angora Gladstone Williamson School* Glen Riddle* Wawa*
Paoli	52nd Street St. Davis Daylesford
Norristown	Spring Garden Temple Univ. Allegheny Shawmont Miquon Ivy Rock Mogees Main Street Elm Street
Chestnut Hill West	Westmoreland Highland
Reading Trunk	Tioga Nicetown Logan
Lansdale	Fellwick Fortuna Colmar Link Belt New Britain Del. Vall. College
Warminster	Crestmont Fulmor
Trenton	Frankford Junc. Frankford Bridesburg Wissinoming Andalusia Eddington
West Trenton	Forest Hills*

*Additional stations eliminated for the Expanded System.

Figure 4-2 lists the stations that need high level platforms, for both the Modernized and Expanded Systems.

As for parking facilities, it has been estimated that a total of 28,389 new off-street parking spaces will be needed for the Modernized System and 52,631 for the Expanded System (See Figure 4-3). It is important to note that these figures are indicators of the future needs of the system's riders; however, further studies of each station's dynamics are needed in order to determine the appropriate number of parking spaces for each one of them. The projected parking requirements for both systems are based on three major components. The first is the distribution of the future ridership among the five counties of the study area. This distribution assumed the present trends of the existing system would continue and the expected origins and destinations of the future ridership would change according to the region's growth areas.

The second component was an estimation of the passenger/parking space ratio for the different counties, assuming that those locations furthest out from Center City Philadelphia will require more parking spaces. Most stations will tend to be of the park-and-ride variety. Therefore, these stations will require a low boarding passenger/parking space ratio. On the other hand, Philadelphia County--which is a largely developed area served by different transit facilities--will require a higher ratio.

Figure 4-2

Existing Stations Requiring High Level Platforms

Modernized System

1. Overbrook
2. Merion
3. Narberth
4. Wynnewood
5. Ardmore
6. Haverford
7. Bryn Mawr
8. Rosemont
9. Villanova
10. Radnor
11. Wayne
12. Stratford
13. Devon
14. Berwyn
15. Paoli
16. East Falls
17. Wissahickon
18. Manayunk
19. Spring Mill
20. Conshohocken
21. DeKalb Street
22. North Philadelphia (Chestnut Hill Line)
23. Queen Lane
24. Chelten
25. Tulpehocken
26. Upsal
27. Carpenter Lane
28. Allens Lane
29. St. Martins
30. Tacony
31. Holmesburg Junction
32. Torresdale
33. Cornwells Hgts.
34. Croydon
35. Bristol
36. Levittown-Tullytown
37. Fernwood
38. Lansdowne
39. Clifton
40. Primos
41. Secane
42. Morton
43. Swarthmore
44. Wallingford
45. Moylan
46. Media
47. Elwyn
48. Darby
49. Sharon Hill
50. Folcroft
51. Glenolden
52. Norwood
53. Moore
54. Ridley
55. Chester
56. Marcus Hook
57. Wayne Junction
58. Tabor
59. Fern Rock
60. Melrose Park
61. Elkins Park
62. Jenkintown
63. Glenside
64. North Hills
65. Oreland
66. Fort Washington
67. Ambler
68. Penllyn
69. Gwynedd Valley
70. North Wales
71. Penn Brook
72. Lansdale
73. Chalfont
74. Doylestown
75. Olney
76. Lawndale
77. Cheltenham
78. Ryers
79. Fox Chase
80. Ardsley
81. Roslyn
82. Willow Grove
83. Hatboro

Expanded System: (in addition to stations identified for Modernized System)

1. Malvern
2. Lenni
3. Glen Mills
4. Cheyney
5. Westtown
6. Nields Street
7. West Chester
8. Noble
9. Rydal
10. Meadowbrook
11. Bethayres
12. Philmont
13. Somerton
14. Trevose
15. Langhorne

Figure 4-3

Parking Space Projections

Modernized and Expanded Systems

County	Boarding Passengers Per Wkday. (1976)	Off-Street Parking Spaces	Boarding Passengers Parking Space Ratio	Projected Boarding Passengers		Est. Board. Pass./Park. Space Ratio	Projected New Parking Spaces(*)		Number Stations		Average Parking Spaces Per Station	
				Modern. System	Expand. System		Modern. System	Expand. System	Modern. System	Expand. System	Modern. System	Expand. System
Bucks	4,000	1,800	2.2	7,936	12,455	2.2	1,807	3,861	7	13	258	297
Chester	3,900	1,100	3.5	7,937	12,454	3.0	1,546	3,051	4	14	387	218
Dela-Ware	15,500	2,200	7.0	31,265	49,062	3.0	8.222	14,154	22	28	392	524
Montgomery	19,500	4,300	4.5	39,202	61,516	3.0	8,767	16,205	31	37	283	438
Philadelphia	76,600	4,800	16.0	156,160	241,913	12.0	8,047	15,360	27	30	298	512
Total	119,500	14,200	-	240,500	377,400	-	28,389	52,631	91	122	315	435

Source: Parking Provisions at Selected Transit Stations--Transportation and Traffic Engineering Handbook; Second Edition, Institution of Transportation Engineers

Self-generated

(*) $\frac{\text{Boarding Passengers}}{\text{Estimated Ratio}} - \text{Existing Parking Spaces}$

The third component was the existing off-street parking, which was assumed to remain available in the future. Therefore, it was subtracted from the total estimate of parking requirements.

The distribution of parking facilities throughout the system should be determined with the aid of a detailed study of the characteristics and role of each station. These are some general criteria for determining where parking should be provided:

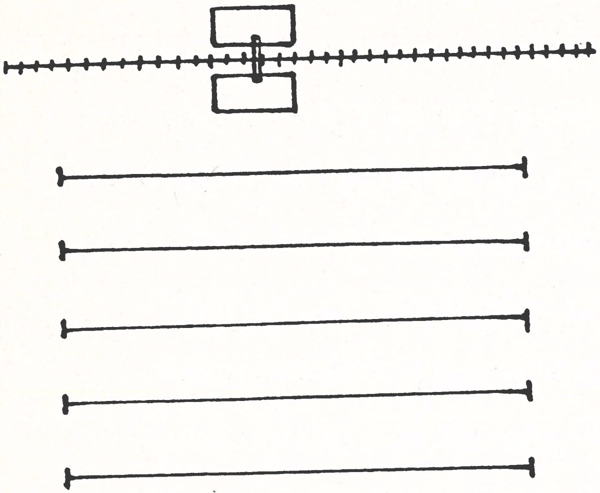
- At new stations where land is available.
- At stations near major growth areas, since the region's land use plan encourages concentrated development in these areas.
- At stations with high projected ridership.
- At stations recommended for joint development.
- At transfer stations.

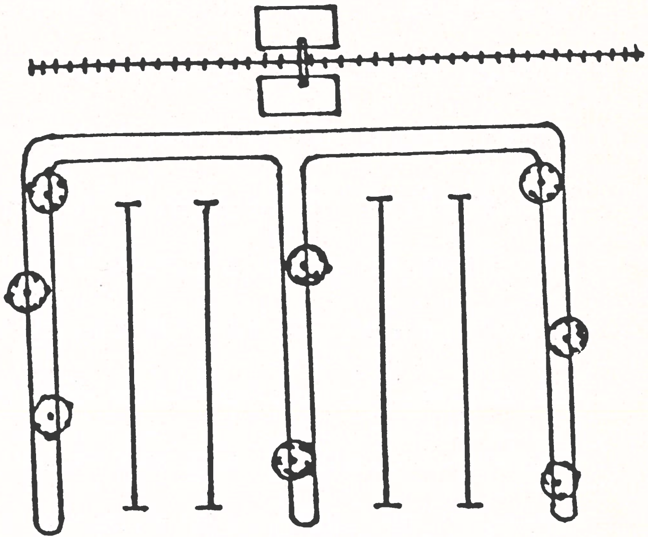
The basic design principles for parking facilities at regional rail stations are:

- The capacity of the lots should satisfy a high percentage of the expected park-and-ride demand.
- The parking areas should be directly visible from the station buildings and platforms. If this is not possible, directional signs should clearly show the way.
- The parking bays should be perpendicular to the train tracks. This makes it easier to walk from the parking lot to the station buildings and platform areas. See Figure 4-4.

Figure 4-4

PARKING SPACE ARRANGEMENTS





- Provide landscaped islands between parking bays which are safer and more attractive walkways to stations.
- Avoid building dead-end lanes.
- Provide 90° parking stalls and one-way lanes in order increase capacity. Because regional rail stations will be heavily patronized, it is important to use the parking areas as efficiently as possible.
- The entrances to parking areas should not come directly off major roads, but should be via station driveways.

In addition to providing of parking, special attention should be given to several stations at or near the proposed multi-purpose centers. Specific design considerations are proposed for these stations according to the surrounding development. The range of possibilities includes shopping malls, apartment buildings, stations for highly developed urban areas and stations for outlying areas with little development. It is important to note that these stations are expected to have a considerable increase in their ridership, which is mainly due to their being terminals or transfer stations, or being close to major regional growth areas. Figure 4-5 lists the stations considered for major improvements. In addition, Figures 4-6, 4-7, 4-8, 4-9 and 4-10 provide a schematic overview of the location of all stations in each line and the mileages between them.

4.3 Potential New Station Locations

The analysis of potential new station locations involved three major considerations. The first one was the location of presently-developed areas and major future growth areas along the new alignments. The second was an analysis of the existing highway network in order to determine locations where easy access could be provided. Finally, an analysis of system alignments and operations permitted new transfer stations to be located.

Eighteen potential station locations are recommended at an early state of development. Thirteen of these are on the Expanded System's proposed circumferential line; two of these are included in the Modernized System (King of Prussia and

Figure 4-5

Existing Stations Considered for Major Improvements

Line	Station
Wilmington	Chester Ridley Marcus Hook
Media-West Chester	Media Secane Morton Lenni West Chester
Paoli	Overbrook Ardmore Bryn Mawr Wayne Paoli
Norristown	DeKalb Street East Falls
Chestnut Hill (West)	Carpenter Lane Chestnut Hill
Reading Trunk	Wayne Junction Jenkintown Glenside
Lansdale	Lansdale Fort Washington Chalfont Doylestown
Warminster	Roslyn Willow Grove Warminster
Fox Chase	Cheltenham Fox Chase
Trenton	North Philadelphia Holmesburg Junction Torresdale Tullytown
Circumferential	Bethayres Langhorne

Figure 4-6

LANSDALE-DOYLESTOWN, WARMINSTER AND FOX CHASE LINES

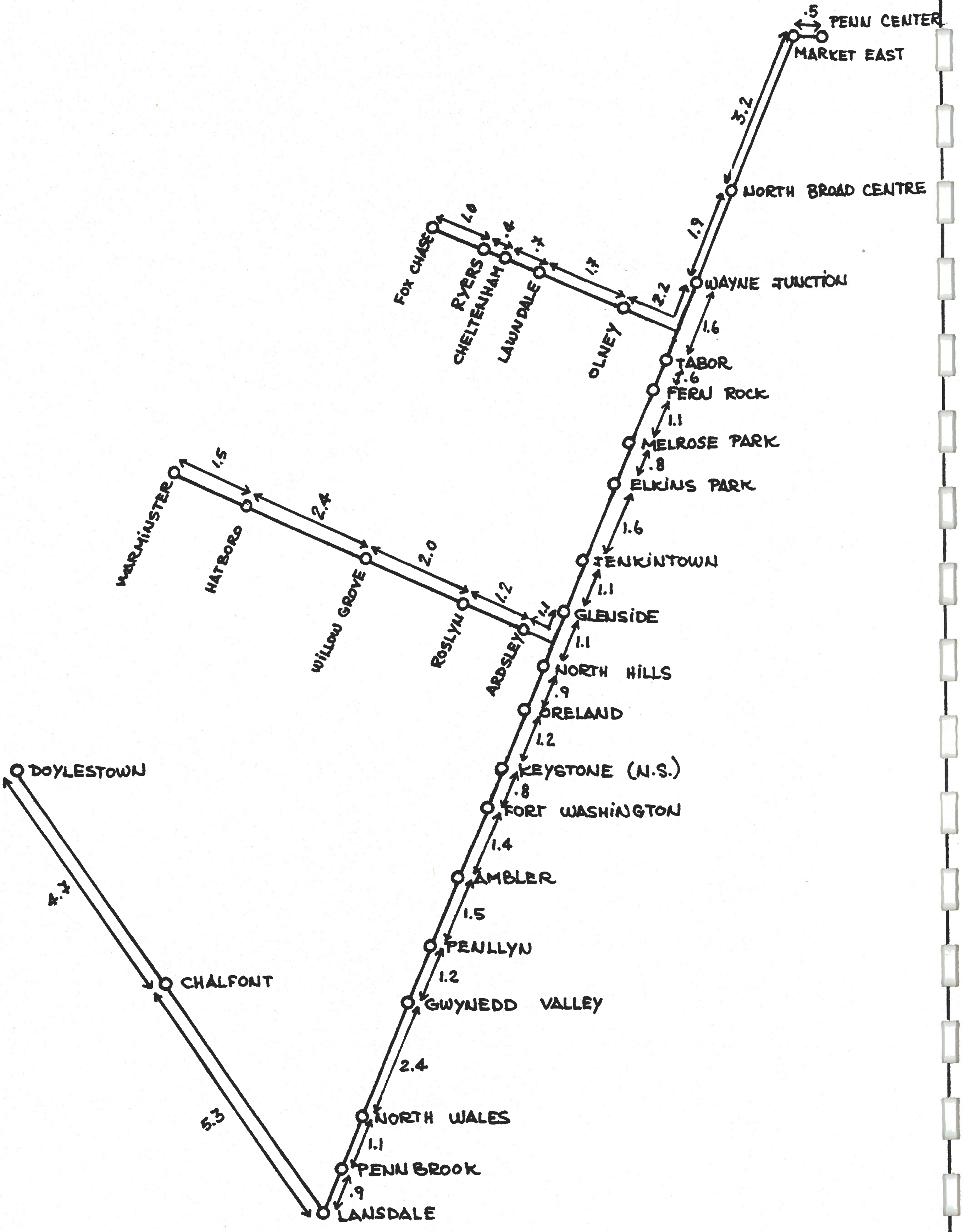


Figure 4-7

MEDIA AND WILMINGTON LINES

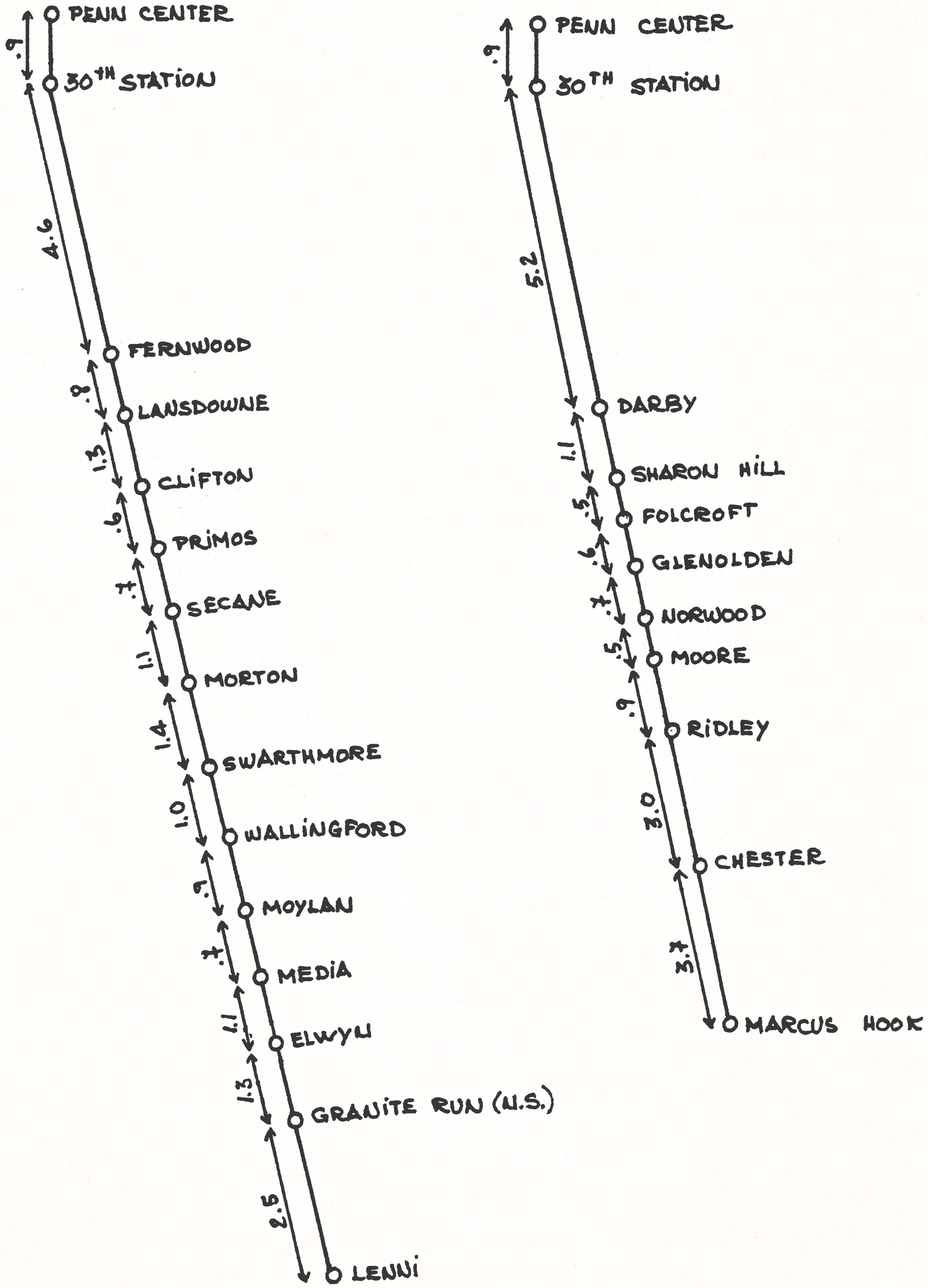


Figure 4-8

NORRISTOWN AND PAOLI LINES

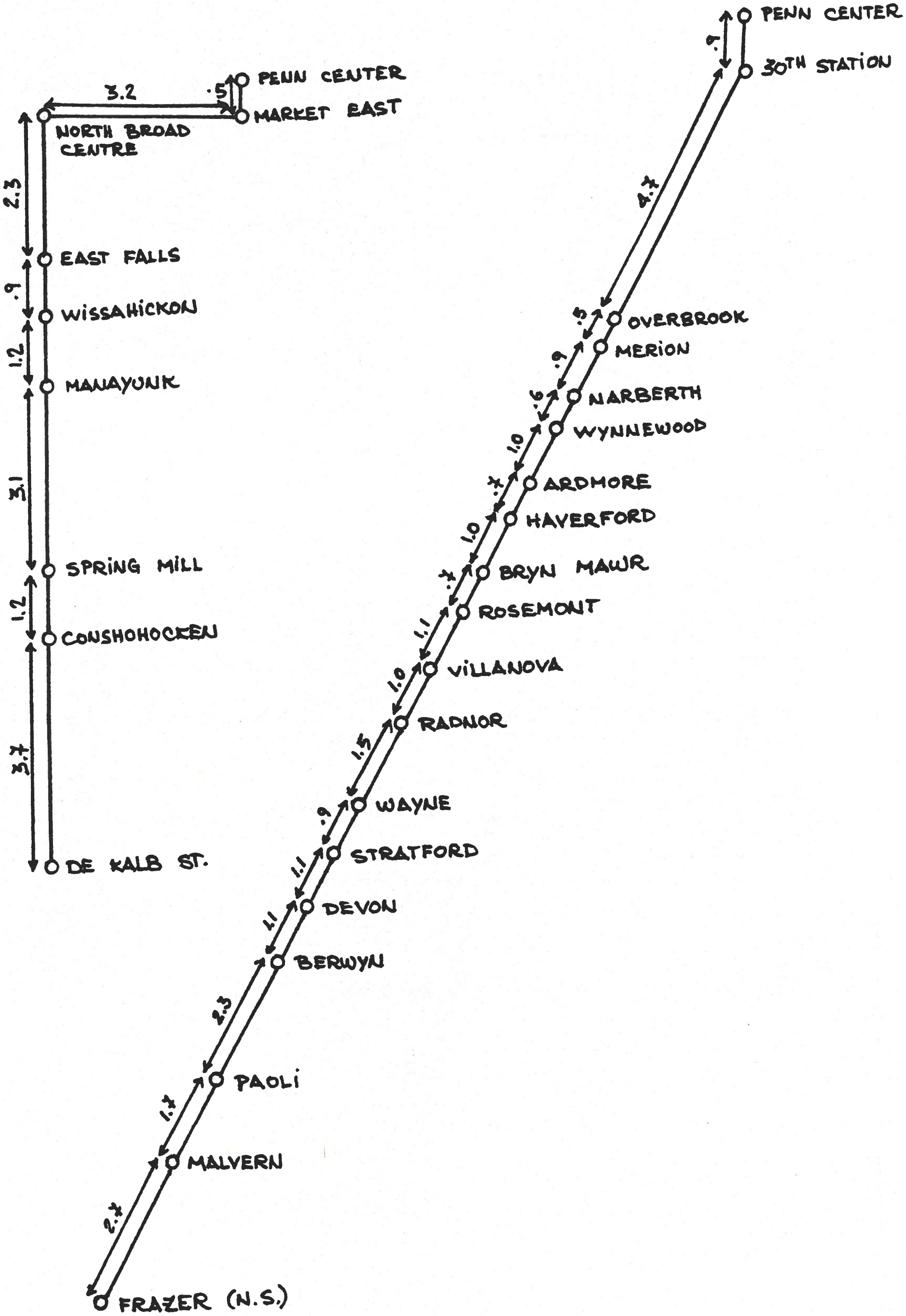


Figure 4-9

TRENTON AND CHESTNUT HILL WEST LINES

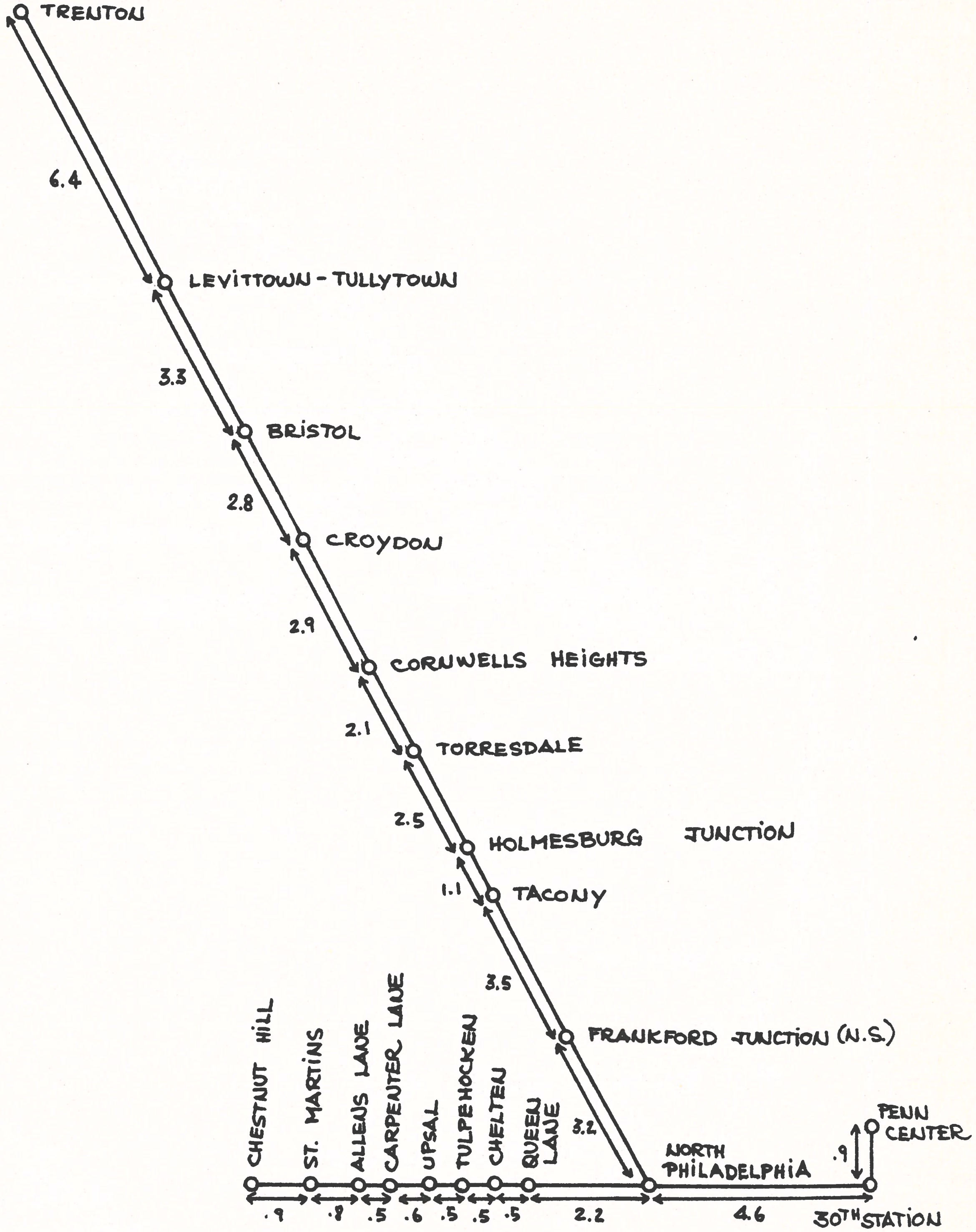
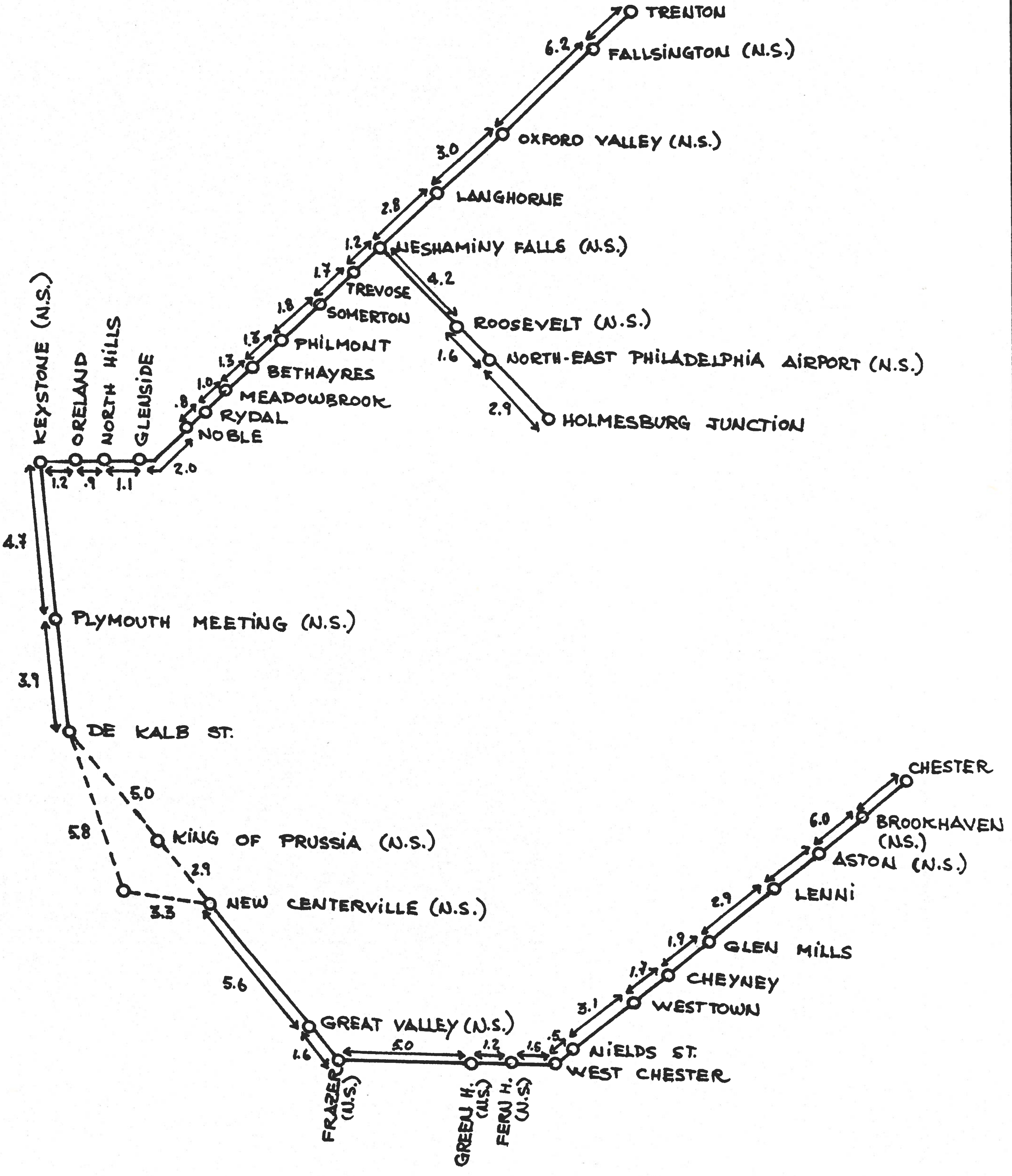


Figure 4-10

CIRCUMFERENTIAL AND NORTH-EAST PHILADELPHIA LINES



Plymouth Meeting). The rest of the stations, all included in the Expanded System, are on the Northeast Philadelphia Line, Media Line, Trenton Line and the Reading Trunk. These stations are recommended for the earliest stage of development, therefore, future alternative locations might be considered according to ridership demand and future growth areas. Figure 4-11 lists potential locations for new stations.

Five potential stations primarily serve major shopping centers; these are King of Prussia, Neshaminy Falls, Oxford Valley, Plymouth Meeting and Granite Run. Where direct access to these shopping centers is not possible, the station area will have a people mover or other special transportation service. All of these new stations offer great joint development opportunities, which will greatly increase the community's use of the stations (and the system).

Other new stations are designed to serve existing and future residential development near the alignments. Examples are Brookhaven, Green Hill, New Centerville and Roosevelt Stations. In addition to serving commercial and residential development, some stations serve other activities such as industry (Aston Station) and air service facilities (Northeast Philadelphia Airport).

Still other new stations are major transfer points: Frazer, Keystone. Both are recommended for joint development, since they provide a captive market for commercial and retail activities (see Figure 4-12).

Figure 4-11

Potential New Station Locations

Line	Station	County	Potential Location
Circumferential	Brookhaven	Delaware	Brookhaven Road and Bridgewater Road
	Aston	Delaware	Mount Alverno Road
	Fern Hill	Chester	West Chester By-Pass-Federal Road 322
	Green Hill	Chester	Green Hill Road
	Frazer	Chester	Sproul Road
	Great Valley	Chester	Highways 401 and 30
	New Centerville	Chester	Forge Road-State 252
	*King of Prussia	Montgomery	If Tunnel: Inner Hall If Bridge: Gulph Road
	*Plymouth Meeting	Montgomery	Germantown Pike
	Keystone	Montgomery	Local 309
	Neshaminy Falls	Bucks	Bristol Road
	Oxford Valley	Bucks	Oxford Valley Road
	Fallsington	Bucks	Trenton Road
Northeast Philadelphia	Northeast Philadelphia Airport	Philadelphia	Grant Avenue
	Roosevelt	Philadelphia	Roosevelt Boulevard
Media	Granite Run	Delaware	Near Middletown Road
Trenton	*Frankford Junction	Philadelphia	Kensington Avenue
Reading Trunk	*North Broad Centre	Philadelphia	Approx. 0.3 miles north of the existing North Broad Station

*New Stations for the Modernized System; all others are for Expanded System only.

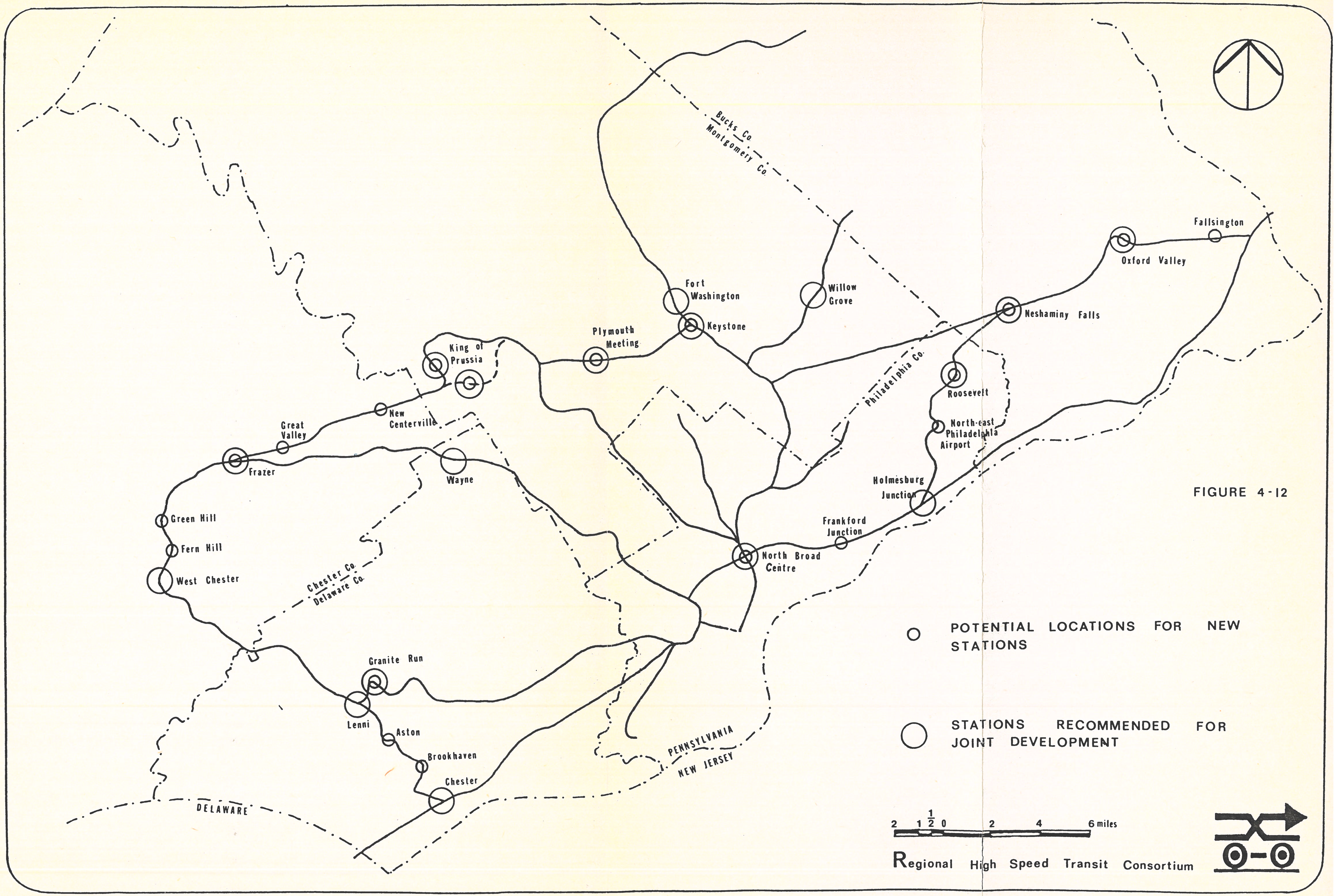


FIGURE 4-12

Bucks Co.
Montgomery Co.
Philadelphia Co.
Chester Co.
Delaware Co.
PENNSYLVANIA
NEW JERSEY
DELAWARE
Fallsington
Oxford Valley
Neshaminy Falls
Willow Grove
Fort Washington
Keystone
Plymouth Meeting
King of Prussia
New Centerville
Great Valley
Frazer
Wayne
Roosevelt
North-east Philadelphia Airport
Holmesburg Junction
Frankford Junction
North Broad Centre
Green Hill
Fern Hill
West Chester
Granite Run
Lenni
Aston
Brookhaven
Chester
POTENTIAL LOCATIONS FOR NEW STATIONS
STATIONS RECOMMENDED FOR JOINT DEVELOPMENT
2 1 1/2 0 2 4 6 miles
Regional High Speed Transit Consortium

4.4 Station Design Requirements

The main purpose of any transit station is to transfer passengers between modes within a transportation network. Station design and planning should maximize the efficiency of passenger movement and should also meet the needs of the major parties involved: the passengers, the operating agency and the community.

The proposed stations for both the Modernized and the Expanded Systems are of the controlled-access type. In these stations, tickets are checked at the boarding areas, entrances and exits, so that the vehicle boarding would not be subject to delays. There would be simultaneous loading and discharging of passengers at all doors along the train. Another characteristic of these fully-controlled stations is that they allow the use of high-level platforms which makes boarding and alighting process easy and fast.

Although the main function of regional rail stations is to allow the movement of passengers between modes, there are a variety of uses which support the overall transit system objectives and, therefore, influence the station design requirements. These functions range from attracting users to the system and processing them through the station to service functions and joint development.

Station access is also very important. In general, there are two types of stations: stations within a highly urbanized area, where pedestrian access through the street system surrounding the area should be given special attention, and the outlying stations, where good highway access is critical. When the station is not an origin or destination point, it must also function as a transfer point; therefore, sufficient space for feeder buses to board and unload passengers, as well as parking spaces, should be provided. Access modes and their relative proportions will vary for each station. However, the convenience of different modes of travel must be provided for when designing stations. Adequate provision must always be made for:

1. Walking
2. Bicycle
3. Bus
4. Taxi
5. Kiss and Ride
6. Park and Ride

A wide range of design considerations have to be taken into account, depending on the particular objectives for each station. However, its design must be based on a very careful analysis of the three affected parties.

4.4.1 The Passengers

The needs of regional rail riders are primarily identified with three major factors:

1. Convenience--Minimum time and distance to the platform, good information, clear orientation, adequate capacity

and circulation flow, and ease of boarding and alighting from the trains.

2. Comfort--Climate control, restroom facilities, adequate waiting areas, cleanliness and aesthetic design. Human comfort requirements are easier to identify because definitive and readily measured standards have been established for temperature, humidity, noise, light, air pollution levels and other similar environmental factors. In cases of open platforms, major concern must be given to weather conditions and environmental quality. In order to protect passengers from the wind and cold, wind screens should be provided in the form of constructed barriers or vegetation. Also, strategically placed infra-red heaters mounted overhead could be an economical and convenient way to provide shelter from the cold where fully enclosed platforms are not feasible.

Other potential areas of human discomfort, such as crowding, delay, inadequate restroom facilities, and lack of seating, are not as easily defined as the climatic factors; however, levels of service can be established for various pedestrian densities on stairs and in corridors.

3. Safety and Security--Maximum accident prevention through safe walking surfaces; good visibility and illumination (which deter vandalism and prevent crime), adequate police protection, emergency response to accidents, availability of emergency exits, stairway design and warning signs near escalators.

4.4.2 The Operating Agency

The requirements of the operating agency can be described as follows:

- Minimum operating costs. The stations have to be designed for low cost maintenance. This includes regular cleaning, drainage and water problems, accessibility to items that will need to be cleaned or replaced, such as lighting fixtures, signs and others.
- Adequate capacity of the transit system and pedestrian areas for peak demand volumes. Good station operation requires sufficient pedestrian exit and entrance facilities, reliable fare collection equipment and adequate platform dimensions. Also, the location of stairways, information signs and concession stands should not interfere with the passenger flow.
- Flexibility of operation, including ability to adapt to different peak travel conditions and other operational problems.
- Good visibility of platforms, fare collection, and other areas to enable supervision of operations and to ensure efficiency, safety, and prevention of vandalism and crime.

4.4.3 The Community

There are two major types of effects of the station on its surroundings: the long-range effects which include the type of development in the vicinity that may be stimulated or discouraged by the station presence; and the immediate effects, which include environmental impact, visual aspects, noise and possible traffic congestion. The design of the station should be aimed at stimulating the desirable and discouraging the undesirable elements in the area.

It is also important to encourage community involvement in the process of designing the station. The objective of community involvement is to get positive feedback from the community, which will be helpful for the designer and will establish a better relationship between the final design of the station and the community in which it is situated.

4.5 Prototype Station Designs

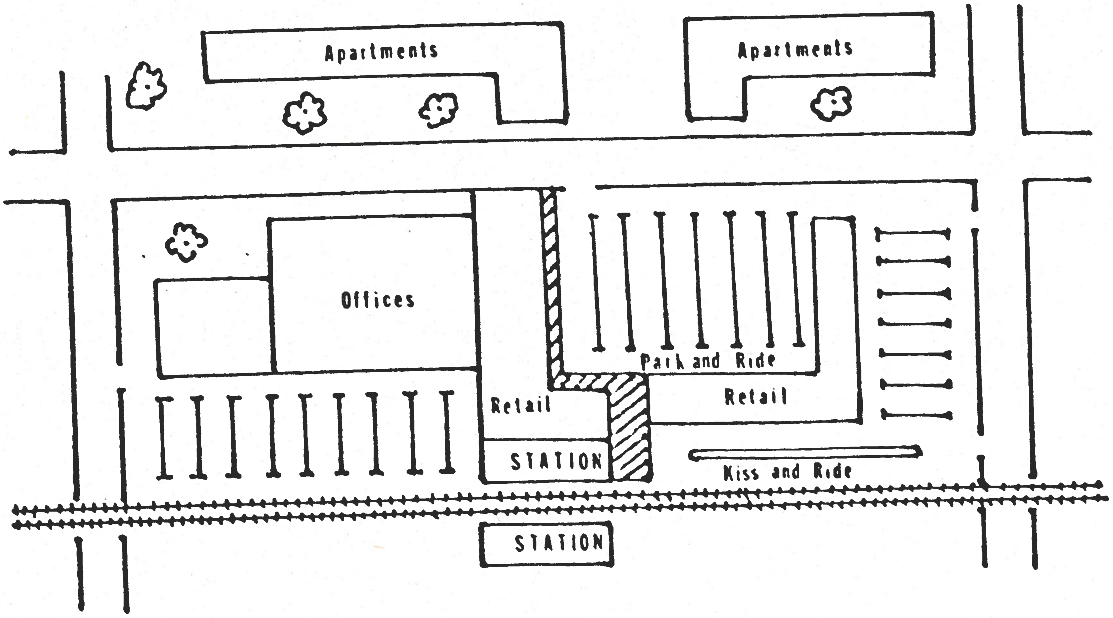
The design of station components should maximize convenience, comfort and safety for commuters. In addition, station components should be designed and maintained well enough to harmonize with the surrounding communities. The success of the proposed systems will depend partly on land use decisions in rail corridors. High-density development should be encouraged along rail lines, especially within walking distance of the stations; in the other hand, as the distance from stations increases, a low-density type of development seems to be more appropriate. In order to illustrate the range of possibilities that might be considered when designing stations' surroundings, four prototype stations are described:

4.5.1 The High-Density Development Station

This type of development includes apartment buildings, retail stores, offices, and other uses within walking distance of the station. The mix of all these activities will provide the station with a large area of life and vitality during daytime and evening hours. It is assumed that the ridership levels of this type of station will mainly rely on the high-density uses at its surroundings. High-density areas such as Norristown, Bryn Mawr, Glenside and Lansdale, follow this prototype to some extent; however, a deficient design and poor pedestrian connections have prevented these stations from their potential. A sketch design of a high-density development station is provided in Figure 4-13.

Figure 4-13

PROTOTYPE HIGH-DENSITY DEVELOPMENT STATION

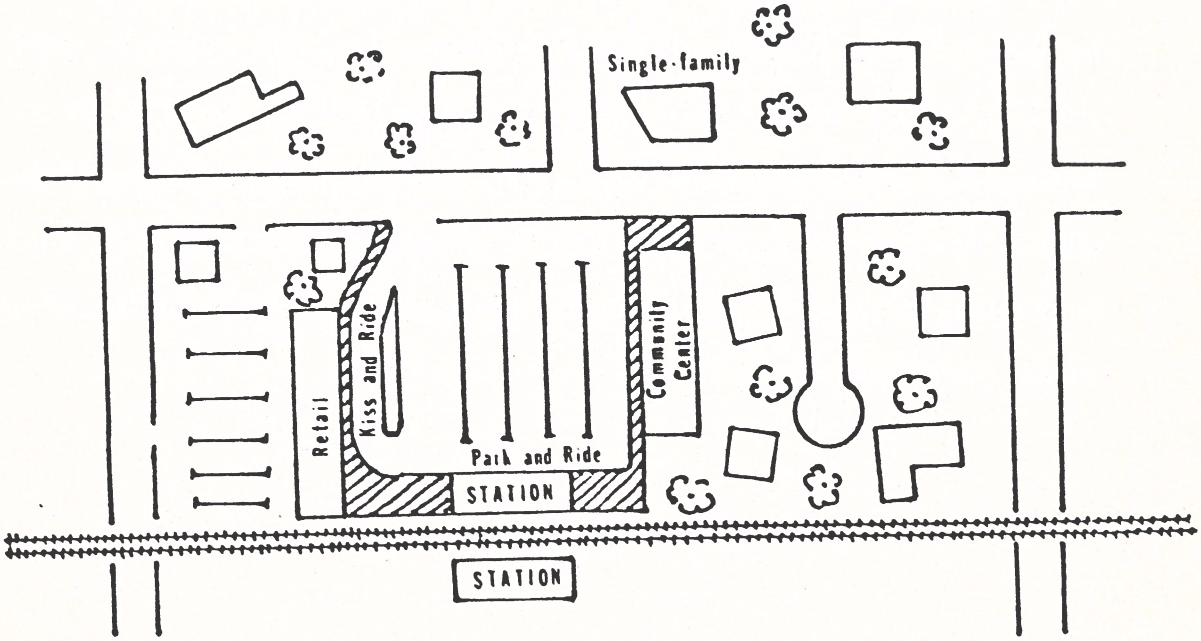


4.5.2 The Low-Density Development Station

The low-density prototype of station has surrounding land use consisting of single-family residential; in addition, it might have local commercial activities and recreational uses immediate to the station. Special consideration should be given to Park & Ride and Kiss & Ride facilities, since the intensity of development will encourage these modes of access. In the other hand, the residential areas should be well related to the station by pedestrian paths. A sketch design of a low-density development station is provided in Figure 4-14.

Figure 4-14

PROTOTYPE LOW-DENSITY DEVELOPMENT STATION

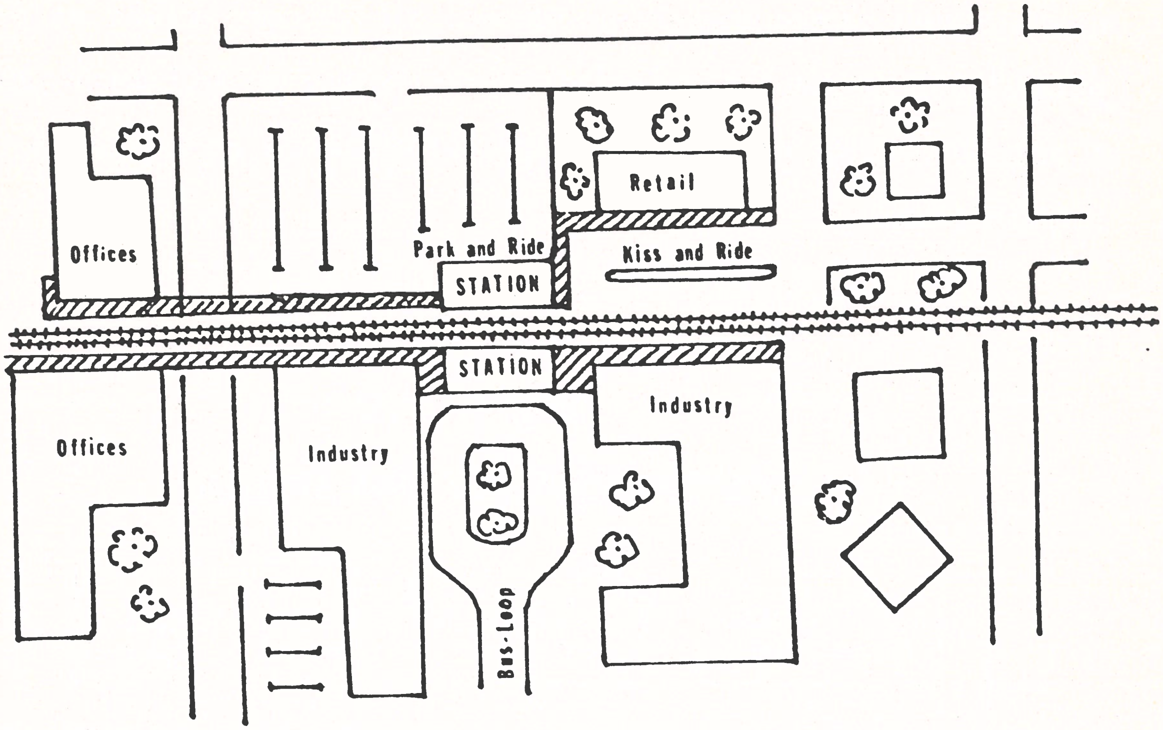


4.5.3 The Employment Development Station

The employment development station has surrounding land use consisting of offices, industries, and supporting commercial activities. This type of station will have well-defined peaking conditions in a typical week day, it will be a destination point in the morning and an origin point in the evening. Therefore, special attention should be given to highway transit modes of access, such as feeder buses; and to connecting pedestrian paths between the employment buildings and the station. The feeder buses will serve industries beyond walking distance to the station. In addition, a certain amount of retail activities will be a major supporter to employees and nearby residents. Due to the mix of activities in the surroundings of the station, parking facilities should be explicitly designated for commuters, residential, commercial, and office uses. This differentiation will prevent unnecessary competition for spaces and will provide a more efficient traffic circulation at the surroundings of the station. A sketch design of an employment development station is provided in Figure 4-15.

Figure 4-15

PROTOTYPE EMPLOYMENT DEVELOPMENT STATION



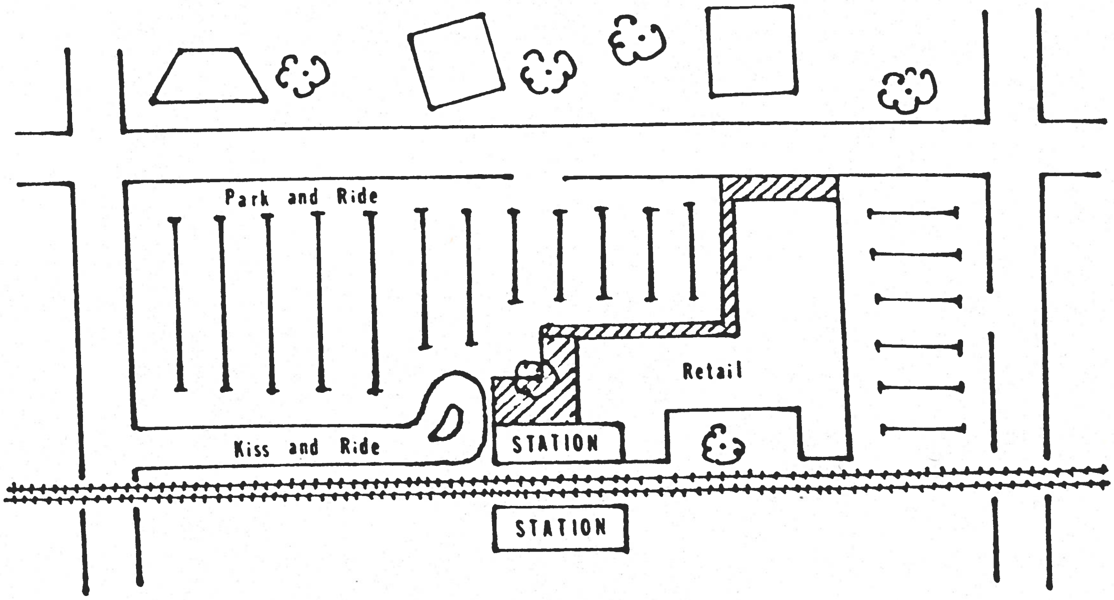
4.5.4 Park & Ride Stations

This type of station differs from the other three previously described in that the station does not necessarily have close ties with the community at its surroundings. Therefore, the immediate land around the station may be isolated from communities by expressways, major arterials or other type of barriers. The major purpose of this type of station is to attract passengers whose access mode is the private automobile.

Park & Ride stations can sometimes be integrated with shopping centers; in fact, certain commercial activities are a convenience for commuters on their homebound trips, and could also be used by non-commuters from nearby areas. These two different markets for commercial activities will not be conflicting since commuters travel the access roads at peak periods while shoppers travel them mostly at off-peak periods. A sketch design of a Park & Ride station is provided in Figure 4-16.

Figure 4-16

PROTOTYPE PARK AND RIDE STATION



BIBLIOGRAPHY--CHAPTER 4

Delaware County Planning Commission. Rail Station Study, 1975.

Delaware County Public Transportation Study. Station Area Land Use and Zoning (1975-1976).

Delaware River Port Authority. Mass Transportation Development Program--Station Design Criteria, 1972.

Delaware Valley Regional Planning Commission. Commuter Rail Passenger Survey Fall 1982, February 1982.

Delaware Valley Regional Planning Commission. Alternative Ways to Work, Rail Shutdown--Tips on Transit and Pooling Options, 1982.

Delaware Valley Regional Planning Commission. Computerized Data Showing Existing Ridership for Stations in the Philadelphia Commuter Railroad System. Supplied by Montgomery County Planning Commission, 1982.

Delaware Valley Regional Planning Commission. Passenger Terminal Facilities in the Delaware Valley Region, 1975.

Montgomery County Planning Commission. A Plan for Revitalizing Commuter Rail Stations, 1972.

Regional Transportation Authority. A Commuter Rail Station Location Evaluation Process: Methodology, 1977.

SEPTA. Commuter Rail Station Improvement Study, 1976.

SEPTA, Railroad Division. Study of Parking Arrangements at Stations on SEPTA Regional Railroad System, 1979.

U.S. Department of Transportation. Land Use Impacts of Rapid Transit, 1977.

Vuchie, Vukan R. Urban Public Transportation Systems and Technology, 1981.

CHAPTER 5

JOINT DEVELOPMENT OPPORTUNITIES

by Joseph Augustyn

5.1 Overview

Real estate development located near public transportation and built to interact directly with the transportation system is defined as "Joint Development." There is a symbiotic relationship between the transportation and real estate components for the purpose of increasing the revenues or profits of both. The third party which benefits from joint development is the community where it is located. Transit patrons benefit from increased accessibility to shopping residence and work places, while the municipal government gets additional revenue from the property taxes which keep pace with rising real estate assessments. It has been shown that UMTA investment in carefully selected joint development projects is likely to be more cost-effective in terms of benefits to the transit system than comparable investment in more conventional projects.

The principal orientation of this regional transit study is toward suburban access rather than toward inner-city travel. Joint development as proposed for this project therefore principally involves retail, office and high density residential land uses adjacent to, rather than above or below transit stations.

Air Rights Development, consisting of real estate projects located above or below a transit station, would be feasible for an expanded transit system as envisioned in this study. This type of development is more costly to implement, However, and also requires much more transit patronage to support it. Air rights development could more easily be implemented in the middle of intensively developed existing land uses, such as a regional shopping mall or office park.

Area Joint Development, affecting a wider area around the transit station, also requires expanded land use planning and capital investments. This type of joint development, involving a number of functional planning projects, could involve schools, medical centers, churches, and sports arenas as well as the more standard forms of development.

5.2 Historical Approach

Joint development projects have been in existence since the early 1900's. It is only the term which has recently become popular. The development of air space for the New York Central's Grand Central Terminal was the first major commercial use of transit air space in the United States. Early projects such as this, however, were realized under different conditions than presently exist in the Philadelphia region. First, railroads have traditionally been private companies with powers to finance joint ventures with private developers. In many cases, the railroad companies had been granted powers of eminent domain. Second, railroads were not constrained by "public good" considerations as is the case today. Third, railroads were recognized as members of the investment community, and as such, were given more consideration as partners in joint ventures. These earlier concepts are important to understand in examining the history of railroad joint development in Philadelphia.

The development of the three-block area known as Penn Center began in 1930 with the construction of Suburban Station. The Transportation Center, completed in 1957, added an office tower, the Greyhound bus terminal and a four level 1,000 car garage. By 1971, three additional office buildings and a plaza were completed. The plaza was publicly financed. The Pennsylvania Railroad and other private companies provided financing for the Suburban Station complex and Penn Center proper. The remainder of the site was subdivided over time, and private companies were involved. At present there are 2.7 million square feet of office space, 500,000 square feet of retail in the underground concourse, a 500-room Sheraton Hotel and an underground parking garage with commuter rail and transit service readily available.

The Gallery at Market Street East was originally imagined in the late 1940's as a 50-acre area, extending five blocks east of City Hall. Active involvement at the 9th and

Market Street site by the Rouse Company, a renowned private developer, did not start until the early 1970's. At that time Gimbels had committed itself to build a new Center City store. The Gallery, co-developed by the city's Redevelopment Authority and Rouse, is a four-level retail mall linking all floors of the new Gimbels store with Strawbridge and Clothier's previously-existing store and the renovated SEPTA station at 8th Street, where connections to the Lindenwold High Speed line are also available.

The Gallery project involved a complex Air Rights Joint Development arrangement as previously discussed. Site and building improvements were funded through a series of HUD grants, and renovation of the transit station by SEPTA was done with UMTA funds. Substantial private investment was also made by Rouse, Gimbels, and Strawbridge and Clothier's. Debt financing was also arranged through a consortium of local lenders. Future plans include connection with the Center City Tunnel linking the Reading lines with Suburban Station.

Penn Center's success was largely due to single ownership which made it easier for the city to obtain desired improvements. The Gallery project relied on public sector planning, land assembly and site improvements. Subsequent leasing arrangements were made with the private developer.

5.3 Lessons Learned

The historical examination of local joint development allows us to apply the lessons learned, in order to design a more effective joint development planning and construction process.

Based on Philadelphia's relatively extensive experience with downtown joint development, the following facts have been established:

1. An assumption of risk and responsibility by the public sector can promote solid commitments from the private sector.

2. The role of one lead agency coordinating the efforts of others increases the efficiency of the project's implementation.

3. The participation of a very capable developer strengthens the feasibility of a project.

4. Consistent long-term management is essential for joint development success.

Formulated from a private business viewpoint and based on its Philadelphia experience, the Rouse Company emphasized the following points as critical to the success of a joint development venture:

1. The city must take steps to make the venture possible. This includes land assembly, rearrangement of utilities, and investments. The city's return includes area revitalization and increased property values for tax assessment purposes.

2. The department stores (retail stores involved with the development) must be committed from the beginning.

3. Planning and design are critically important and must deal creatively with the special problems of the particular situation. The design must be generous in its detail and evoke warm responses and affection.

4. There must be a searching sensitivity to the surrounding built environment, what its needs and yearnings really are.

5. The (retail) space must be carefully merchandised to produce the necessary mix of uses to attract both tenants and customers.

6. It must be capable of being financed, and for the present, at least, that means overcoming scepticism and disbelief.

Additional lessons have been learned from examples elsewhere. Just as the local experience should be applied, so should the experience of other cities. General conclusions about involvement with various joint development projects are as follows:

1. Case studies show that joint development is achieved through active planning and deal-making during the early stages of route selection, station design and acquisition of land. Planning includes the activities of the transit authority and other public agencies. Deal-making refers to the contracting, bargaining and negotiation between the public agency and the private developers.

2. The private developer is most attracted to sites for which the appropriate zoning has already been established to allow uses and densities appropriate to market demands.

3. Developers prefer sites which minimize construction challenges while maximizing pedestrian flows and commercial potential.

4. Developers prefer dealing with a single public agency with the power to act unilaterally.

5. Developers are attracted by the availability of unencumbered sites already assembled and prepared in advance for immediate use.

6. To promote effectiveness of both joint development and the transit system, entrances should be placed on sites with strong existing uses or redevelopment potential.

7. Ideally, the lead public agency should have the power and finances to buy, sell and lease real estate, and to provide financing and development incentives.

8. Developers should be selected according to their experience and the financial resources necessary to complete the project.

5.4 Proposal

The study team's exploration into the actual experiences of joint development, both locally and outside of the region, leads directly to the joint development proposal for Philadelphia's regional transit system. This approach to joint development is an action-based development strategy.

This study emphasizes the public benefits to be obtained from a modern high speed mass transit system. Therefore, the first step is to identify the goals to be achieved for the public good through joint development:

1. Economic Development. To obtain investment growth for the community in the form of increased job opportunities and attracting and retaining business. To obtain an increased return for the private investors.
2. Increased Ridership. To increase ridership by creating intensively developed, highly integrated projects which attract people to transit stations.
3. Growth Management. To consolidate the regions growth pattern in order to conserve energy, alleviate pollution and increase the efficiency of municipal services and developer investments.
4. Urban Design Improvement. To improve the efficiency and aesthetics of urban form.
5. Cost Recovery and Assistance in Transit Financing. To recoup public capital investments. To obtain revenues for the transit system in the form of rent or sale of property.

Joint development will be achieved through a three-stage process. Each phase must be completed sequentially, accomplishing all subtasks in each phase, otherwise the program could fail. Initially, a lead agency will be established to represent the public sector, encompassing both the transit agency's interests and those of the community. The lead agency will be properly staffed with people with real estate and finance experience.

Phase 1:

1. Determine which stations presently have such necessary components as arterial road connections, economic

viability, development potential, supporting infrastructure and existing or anticipated high density to support joint development. A proper assessment of potential political support is critical.

A preliminary list of stations identified in the proposed modernized and expanded systems which appear to have the necessary physical components to make joint development successful is as follows:

a. King of Prussia
b. Granite Run
c. Oxford Valley
d. Neshaminy Fall
e. Plymouth Meeting
f. Frazer
g. Keystone
h. Lenni
i. Holmesburg Junction
j. Willow Grove
k. Chester
l. West Chester
m. Fort Washington
n. Wayne
o. Roosevelt
p. North Broad Centre

2. Determine the direct impact zone at the selected stations or locations which would require flexibility in land use mix and density. Based on studies of travel behavior associated with land use adjacent to rapid transit stations, the following impact zone area criteria are proposed:

a. Since walking is critical to the real estate-transit connection, the outer limits of the impact zone will be set at approximately 3,000 feet from the station, beyond which there is a sharp drop in people's willingness to walk to the station.

b. Parking provisions within the 2,000 to 3,000 feet range would be provided according to modal split.

c. To promote high ridership, it is necessary to provide the most direct and efficient access from the development to the transit system itself.

3. Based on a market analysis and a financial feasibility study, determine the optimum land use mix which achieves maximum ridership at desired times, and provides the greatest rate of return for both the municipality and the developer. For example, one consideration is the fact that retail development produces off-peak transit trips to offices. Minimum and maximum amounts of the different land uses should be established to allow flexibility for the developer. The uses would generally include office, residential, commercial and restaurant.

4. Determine public inter-agency cost-sharing arrangements, and begin preliminary land assembly by obtaining land purchase options from the present owners within the impact zone. This must occur before Subtask 6 in Phase 1.

5. Determine the total community costs and benefits for each respective joint development location.

6. Present the plan to each municipality for approval of proposed land use and zoning changes to accommodate the development.

Phase 2

1. Determine the optimum financial arrangement for the public agency. The land values will have increased from the rezoning. Whether to exercise the land purchase options or sell them, and whether to lease or sell the land to developers should be decided now.

2. Potential developers, lending institutions, investors and tenants should be solicited. Arrangements should be made through deal-making, keeping in mind the lessons learned from previous experience.

3. Formal land assembly should take place.

4. Shift the financial and physical burden of preparing sketch plans, preliminary engineering plans and reports from the lead agency to the developer.

6. The lead agency will coordinate all permit requirements on the local, county and state levels.

Phase 3

1. Finalize engineering plans.

2. Take bids and begin construction.

3. Manage the project

5.5 Constraints

In view of the potential advantages of joint development, it is a wonder that so few joint development projects have been undertaken. The reason is a failure to come to grips with related constraints. The following issues must be addressed and resolved before full commitment to joint development is made:

1. Fundamental values related to the role of public agencies in private business deals must be examined.

2. Federal, state and local rules and regulations which may affect the required procedures should be analyzed.

3. The legal and financial restraints of supplying seed money for initial market analysis and land option purchases must be considered.

4. The local political problems of mustering adequate support for the necessary zoning changes.

CHAPTER 6

OPERATIONS

by Peter Bromley

6.1 Introduction

Operations is an area of transit planning which, while always recognized as necessary, does not always get the attention it deserves. This has been slowly changing in recent times because of the need to develop more efficient transit operations on one hand, and the realization that the best-built service is still a failure if it fails to attract passengers, on the other. While, in the past, time and effort were spent tailoring service to match travel demand, much less time was spent stimulating demand and studying the characteristics of latent demand as well as the preferences of those already riding the system.

This section will deal with both of these concerns, i.e. that of building a more efficiently run rail system and also of developing a service which people will find an attractive means of getting around. Thus, this chapter will consider marketing of the rail system (which is also related to how the system sells itself to passengers), as well as operational practices, labor issues and scheduling.

6.2 Summary

Stated briefly, the team recommends:

1. Enhanced intermodal connections, particularly with other transit services
2. More innovative and aggressive marketing techniques
3. Improved information systems
4. More attention to security in station design and system operation
5. Ultimate reduction in labor requirements through operational efficiency (including one-person operation), the introduction of high level platforms, more door channels per vehicle and wider vehicle aisles
6. Immediate implementation of fare collection procedures which discourage on-board ticket sales, and eventual conversion to automatic fare collection
7. New scheduling, based on the operation of most trains through the Center City Commuter Connection.

6.3 Intermodal Connections

This chapter deals in depth with ways of integrating train service with other transit services currently operated by SEPTA. The issue is important for a number of reasons. At present, very few use public transit as a means of reaching the commuter rail service. Many walk and the remainder are about equally split between kiss-and-ride and park-and-ride. As the team's new alternatives are presented, however, it becomes immediately clear that the systems will depend for some of their additional ridership upon some level of reverse commuting and intra-suburban trips. Even if one were to provide vast park-and-ride lots at great expense, and special kiss-and-ride areas at each suburban station, one would only have been able to solve the problem of access for those users. They must still be able to quickly, safely and conveniently get from the rail station closest to their destination to their final destination. Some, of course, will be able to walk but walking in outlying areas is not always so safe and easy as it is in Center City. Moreover, thanks to a development pattern which until now has been largely shaped by the automobile, the distances are greater. The point is that feeder service by public transit is desperately needed at these suburban rail stations. If specialized service can be offered by local companies or by the shopping malls for their employees and patrons, so much the better. But high quality, high frequency feeder service should be operated at these stations for all other patrons of the system. Properly operated, it should expand the service area coverage for each station.

Planning a rail trip to some destinations makes one quickly realize why few people travel there by commuter rail. Part of the problem is alignment, which is dealt with more fully in Chapter 2. But a large part of the problem is also scheduling and connections. Intermodal transit connections between rail and virtually any other mode are abyssmal in most locations. Bus stops in the suburban areas are generally located at greater distance than necessary from the stations, the stops themselves are unmarked and schedules are, as often as not, unavailable. Even if one were able, by some stroke of luck, to acquire a printed schedule, it would tell precious little about the actual times of bus arrivals and departures. These often seem to bear little or no relation to the schedule, leaving transit-dependent riders, quite literally, out in the cold. But even if the buses ran on time, there is little reason to believe that many people would want to transfer between bus and rail since, aside from the fact that the two systems often come into close geographical proximity, there is little relation between the two as far as scheduling is concerned. Buses with hourly headways can be scheduled to arrive between trains operating under the similar hourly schedules. The idea of one line's ridership supporting the other receives mostly lip service, but little more has yet been done than that.

At present, unfortunately, only 2 percent of the commuter system's riders get to the train by public transit. A somewhat greater percentage use the system on the city end of their journey, usually in Center City Philadelphia. This is attributable to service in Center City being quite predictable in its routes, having a high service frequency, belonging to part of a true network of dense routes and the practice of allowing free transfer to City Division services for monthly TrailPass buyers. SEPTA has taken some of the steps necessary to facilitate train-bus transfers in town, although more could still be done. Not all of these factors are universally applicable for suburban routes.

In order to improve the situation, special measures could be applied to the suburban bus routes. Even assuming roughly the same network that now exists, steps could be taken to increase the coordination between the train and other suburban services. True, timed transfers may not be possible between every train and connecting bus route, but steps should be taken to determine the routes which would have the greatest potential for intermodal connections. Ridership on both the rail and connecting bus lines needs to be analyzed. Where heavy traffic at transfer points seems likely, some effort could be put into coordinating the two services, most probably by rescheduling the connecting buses. Particularly in these cases, mention should be made in both bus and train schedules of the close interconnections available.

6.4 Marketing

As has already been noted, commuter rail service in this region is expensive. It is usually even more so when half-empty trains rumble up and down the tracks. Any kind of upgraded system must incorporate a marketing element that will tend to persuade people to leave their cars behind. Philadelphia's commuter rail system is not like any other part of the transit network. Its ridership profile contradicts time-worn assumptions about who rides the rails and why they ride. Although it is true that most current riders are traveling to their downtown jobs, it is also true that it is not ridden entirely by wealthy suburbanites. About one-quarter of the daily weekday ridership comes from within Philadelphia proper. Almost one-third have household incomes of less than $15,000 a year.[1] Many of these less-wealthy riders depend on the train during the weekend as well. Because many parts of the region are poorly served by rail, it is neglected as a means of travel to anywhere but center city. Even for a continuation of the commuter rail system, more should be done to promote the use of the train for other destinations and for other purposes. Of course, the modernized (Alternative I) and expanded (Alternative II) systems offer still more potential in this area.

Marketing of transportation systems is a relatively new concept. It was always assumed in the past that people would learn about transit service by word of mouth or seeing bus stop signs on the street and then would use the service provided. Schedules were generally printed showing the route and the times the service was offered. No particularly determined effort was made to compile the schedules into a single source except, occasionally, by private concerns. Also, there never seem to be enough printed schedules to go around. Bus drivers, who are supposed to carry them, rarely seem to. Nonetheless, transit officials are beginning to show increased awareness of the public's "right to know." In many cases, suburban route schedules are now compiled into convenient books. Similar booklets for city routes, compiled by area would also prove valuable. This is particularly true in view of the increasing number of special traffic patterns downtown, designed to provide better traffic flow, which have meant more complicated routes. Moreover, most routes vary their headways during the day and start and stop operation at certain hours. In addition to a simple route map, this information should be included in the booklets, which should be available at bus and train stations. On board the bus and trains as well, more detailed bus schedules should be available which show running times to various points (particularly transfer points) along the route.

SEPTA has recently put together interesting booklets on the ways in which transit could be used for sightseeing. However, some irritating errors in the books (which were prepared for the Bicentennial and never distributed) contribute to an unfortunate waste of marketing potential. SEPTA should prepare new books for use by sightseers, showing the interesting places that are within walking or transfer distance from regular transit stops. In the case of the commuter rail system, surely, booklets would be very helpful. In these local chambers of commerce would doubtless be delighted to include their towns' historical landmarks, cultural facilities and other points of interest. The costs would doubtless be minimal since businesses would be solicited for advertising oriented toward both tourists and residents. In addition, coupons could be included which would give the bearer a discount on food or special services when accompanied by a train ticket. The coupons could be sponsored by individual businesses or chains. Similar guides could be put together for shopping and recreation. All of these new publications should be widely available throughout the system, but particularly on the commuter rail system.

Lastly, the "TrailPass," the monthly pass for the commuter rail system as well as city transit division routes, needs to be better promoted. The fact that it entitles the bearer to unlimited trips within Philadelphia and cheaper fares on the system everywhere else should be emphasized. But this would only partly tap the potential for special fares and connections. Suburban fare structures as they now exist on SEPTA, are equitable insofar as they charge more to those taking longer trips. But unless one rides the bus into the city everyday, there are no discounts for regular riders. If the system is to encourage more reverse commuting and suburb-to-suburb commuting via mass transit, some incentive for regular riders and particularly those who reach the train from the bus and vice versa needs to be offered. This will become particularly important as the network becomes more regional, even through the mere institution of the Center City Commuter Connection. Of course, in Alternative II, the Expanded System, the relationship between city and suburban service will have to be even more carefully defined. Finally, the possibility of some sort of reciprocal fare arrangement with New Jersey Transit's and PATCO's services also needs to be explored.

6.5 Information Systems

Expanded schedules, guides and promotions play a role in providing better information to transit patrons. But that only begins to define the information necessary to operate the current commuter rail system. Even improvements such as the Center City Commuter Connection will require the provision of improved information. There are currently plans to install closed circuit TV monitors to signal the impending arrival of trains at the Market East Station at 11th Street. This technique for alerting passengers leaves much to be desired. Since there are currently no front or side destination signs on the Silverliners, a simple, visual image of a commuter rail train does little to enlighten passengers. Presumably there will be public address announcements to inform passengers when their train is arriving at the station. The problem is that at both Market East and

Penn Center (which may not be equipped with closed circuit TV), passengers will be made to wait on the concourse level. This means that they need to have advance notification of train arrival so that they have time to negotiate the steps en masse before the train arrives. Public address announcements are not always clear, and can be easily misunderstood by even native commuters,much less visitors (foreign or domestic). Once the tunnel is in full operation, trains will be coming through to many different destinations. There will no longer be the luxury of long station dwell times, so announcements will have to be made quickly, without calling the trains' stops, and are unlikely to be repeated.

A visual display board of the type used at Penn Center or, even better, by Amtrak at 30th Street, would be very helpful and, in fact, such a system is almost an absolute necessity with the short headways between trains present in the tunnel during rush hours. Such a board should be placed in a central position at concourse level at 30th Street, Penn Center and Market East stations. In addition, large system maps should be very much in evidence showing the current service and stations. Individual line maps could also be displayed showing stations along the line. Finally, at platform level, a much simpler board could be employed, with a list of the lines and a light beside each to indicate which line the next arriving train on each track serves. Similar, though less complex, mechanisms should be installed at the transfer points in the expanded system (Alternative II). These would be Trenton, N.J., Oxford Valley, Neshaminy Falls, Holmesburg Junction, Wayne Junction, North Broad Centre, Keystone, Glenside, DeKalb Street (Norristown), Frazer, Lenni and Chester (City). In addition, trains will be equipped with front and side destination signs. Automatic train monitoring equipment has been budgeted for at these stations to help the controllers identify trains. It should be a simple process to use this information for station message boards as well.

Finally a more complex network will doubtless mean somewhat greater confusion for those who are not regular system riders. Much of this can be cleared up with good graphics, but it should be supplemented by ample phone lines and operators who will cheerfully answer prospective patrons' questions. In addition, free phones for this purpose should be located in each station.

6.6 Security and Safety

The issue of security is important. Most crime on rail transit systems occurs in stations.[2] Thus, the issue has much to do with station design, dealt with more fully in Chapter 2, but it also has implications for the manning of stations. Ultimately, the regional nature the Expanded System (Alternative II) may raise worries in some communities about the safety of the stations and the safety of those riding the system. Emergency call boxes should be located on all station platforms and in all trains, as on the Washington Metro. On the platforms, these should be connected directly to local police; on the trains they should signal the train attendant of trouble on board. Since central control personnel will be aware of the train's location, help can be quickly dispatched.

There are some stations which over the years have acquired such a bad reputation for safety that people genuinely fear getting off the train there. Other than the fact that this gives the system a negative image, it is also directly counter-productive to the ultimate goal of having rail stations acting as development nodes. Much can be achieved with a brightly-lit station without blind corners. It will be necessary to have uniformed transit police (or even private security police) particularly in evidence at "problem" stations, and closed circuit TV at all stations to make riders aware that the operating agency is concerned about their safety and will not allow them to be threatened or hurt while in its charge. What happens beyond the station is another matter, but at least the operating agency has provided a safe oasis upon which the community can build.

6.7 Labor

At the heart of the commuter rail system's woes are its labor problems. Under current operating requirements, a three-man crew is required on every train, even if it is only one car long. Extra trainmen are generally added during the rush hour, and these men must work a minimum of forty hours (though they are paid for five 9-hour days or forty-five hours). Regular trainmen, conductors and engineers do even better: they are generally hired to cover two peaks and thus work twelve hour days, but are paid for sixteen hours per day. In addition, there is a mileage charge figured into each employee's daily wage. In an effort to alleviate some of the labor costs, SEPTA has recently introduced two-man crews on most of its runs with an extra trainman hired during rush hour. Since these men are currently without a contract, with work rules a subject of negotiation (legally, they remain between employers), it is difficult to say how this issue will resolve itself. Reducing crew size should, however, be accompanied by many similar and supplementary actions, since operating procedures have been built around oversized crews for a long time. Without reassignment of duties, two-man crews may prove to be inadequate to properly run the trains.

The duties of the conductors and trainmen include, occasionally, counting passenger ons and offs, raising and lowering train platform step covers (traps) to conform with station platform height, opening and closing doors, announcing stops, starting the train after passengers have boarded or alighted, and fare collection. All of these jobs can be modified or consolidated to speed up train operation and reduce crews and, possibly, even fleet size, thus reducing operating costs.

The present operation at stations wastes a great deal of time. Today, most of the stations have low level platforms. A few exceptions occur at a few stations at the end of the line and in the busiest stations on the Penn Central side (30th Street and Penn Center). Reading terminal has low level platforms, but its replacement, Market East, will be equipped with high-level platforms. The advantage of high-level platforms, in general, is that they allow quicker boarding and alighting of passengers (at least twice as fast). But on the current commuter rail system, passengers must be able to get on and off at both high and low level platforms. This has been accomplished by equipping the vehicles with a hinged metal cover (trap) for the steps, which is lowered over the steps to allow high level platform boarding and alighting and raised to allow the use of the steps at low level platforms. While the traps are raised, the vehicle doors cannot be shut, making riding on the train vestibules exceedingly dangerous.[3] Thus part of the conductor's or trainman's responsibility is to ensure that all passengers have cleared the vestibule before signalling the engineer that the train may be started safely.

The commuter rail cars currently in service have only one convenient entrance in the first car. There is a second entrance through the driver's cab but this is almost never used except, on occasion, at high-level platforms, since it would otherwise mean moving the driver out of the way, raising the trap door, allowing passengers to get on or off, then replacing the trap and allowing the driver back in position. Needless to say, this would be very time-consuming. The rear car of a two-car set does have two convenient doors, one at each end, but most often the door furthest to the rear is kept shut during the entire trip and the trap is never adjusted. What this means is that for a two-car set, only two doors are usually available for entry and exit. four-car sets have six doors available, a slight improvement, until one considers the larger number of passengers involved.

Because the vehicle doors cannot be fully shut once the traps are raised, vestibules are provided at both ends of the car by a hinged door which can be opened by either passengers or crew. This further slows boarding and alighting, and is an inefficient use of space in the car since, as previously stated, no passengers may be carried in the vestibules while the train is in motion.

Commuter rail cars are designed for maximum passenger comfort, and while passengers are not guaranteed a seat, it is quite likely they will be able to find one on most occasions. This is accomplished through the use of 3 + 2 seating. While this is an optimum means of increasing seating, it does narrow aisles considerably. Narrower aisles mean slower passenger movement through the aisles and slower boarding and alighting.

All of these concerns go beyond a study like this one. Once the Commuter Connection is in place, even the current system will have to find a way of speeding up passenger movement. Previously, Center City stations were stub-ended and passengers could take their time getting off. In the future, a delay in the tunnel will slow all operations down. There will be no time to wait for tardy passengers.

There are several measures which could be used to speed up passenger movement, shorten dwell times and make more efficient use of labor. It would help to use vehicles with wider doors and more of them. As long as there remains the issue of the traps blocking the doors, this cannot be done safely for low-level platforms without further partitioning the cars and adding more crew members or installing mechanisms which would automatically adjust to low-level platforms such as are used on some light rail systems. As long as low-level platforms remain in use, these costly alternatives are the only ones available.

It is with this in mind that the study team has recommended converting all stations to high-level platforms at the outset. This will eliminate the problems of the traps and speed up boarding and alighting. The vestibules will no longer be dangerous places to be, since the doors may be closed during the entire trip. As long as this is so, the vestibule partitions may be removed and the whole space used for passenger accommodation.

In addition, a single train operator can supervise boarding and determine when passengers are safely aboard, since they need no longer clear the vestibule for the train to start. On the newer Silverliners, the doors can be closed with the push of a button. This function should be centralized so that one operator can do it. As long as only the one train operator is performing this function, it should be combined with the engineer's duties, since the latter is idle otherwise during station stops. Announcing upcoming stations should also be part of the operator's job.

As long as all doors are safely controlled from a single location, additional, wider doors can be added to the existing cars and built into the specifications for all new cars. For instance, three double-channel doors per car as proposed for the new cars will mean up to six times faster boarding and alighting for high level platforms and as much as twelve times faster entry and exit than possible now at low level platforms.[4] In order to speed up movement through the car, the team recommends 2 + 2 seating in new cars and removing one seat on every row in the Silverliner IV cars to produce a wider aisle.

Under the commuter rail scenario (first phase of Alternative I), two-man crews would be more than adequate for two-car trains if the above recommendations are implemented. An additional crew member would be added for every two additional cars. This would leave conductors and trainmen with responsibility only for fare collection. But this system is currently quite inefficient as well. Passengers buy tickets from station attendants at the busier stations or on board the train at other stations. In any case, station attendants are usually only present for the morning rush hours and early afternoon at the outlying stations. This leaves trainmen and conductors with responsibility for taking the tickets of those who have them and selling tickets to all others. A small penalty is applied to those who did not buy a ticket from a station ticket agent if one was on duty.

Currently, the fare system is a zonal one with five different zones. Ideally, tickets and seat checks are meant to stay in holders in front of each rider and as each zone boundary is passed, seat checks and cancelled tickets are meant to be taken by each trainman or conductor. At the next zone boundary, each patron without a ticket is asked to pay for the additional zone he is riding through. Unfortunately, this system is rarely employed in practice. At its best, it requires the conductor to remember who has a "TrailPass" and who got on at the last stop. When more doors begin to be opened with less supervision and particularly as the system expands (Alternative II), a more efficient system of fare collection must be employed.

Modernization efforts must include automated fare collection, discussed more fully in Chapter 3. Until this technology is applied system-wide, it is suggested that very heavy penalties be applied to on-board ticket purchases when ticket offices are open. These penalties should amount to almost the full price of the regular fare. This should restrict on-board fare collection to exceptional circumstances. This policy would be attractive from a security perspective as well. Some additional steps should be taken to tighten security on-board before a problem develops. On-board safes, which crews could not open, perhaps modeled on existing bus fare boxes, would make the prospect of robbing a train less attractive. Passengers would simply have to have exact change for their fares.

6.8 Scheduling

The issue of scheduling is largely a technical one of matching components of vehicle capacity, speed, line length and passenger demand to accommodate peak hour flows. The more technical aspects of this are discussed more fully in Appendix III. It is enough here to discuss some of the operational improvements that have been made by the study team, the pairings of the lines and how it will operate.

The group analyzed current passenger volumes at all stations, and eliminated those stations with very little patronage. While this does have the effect of reducing area coverage, it reduces the number of stops on the lines and the capital and operating expenses related to stations. Together with the institution of high-level platforms, the speed increases were made, as shown in Figure 6-1

Figure 6-1

Operating Speed Improvements

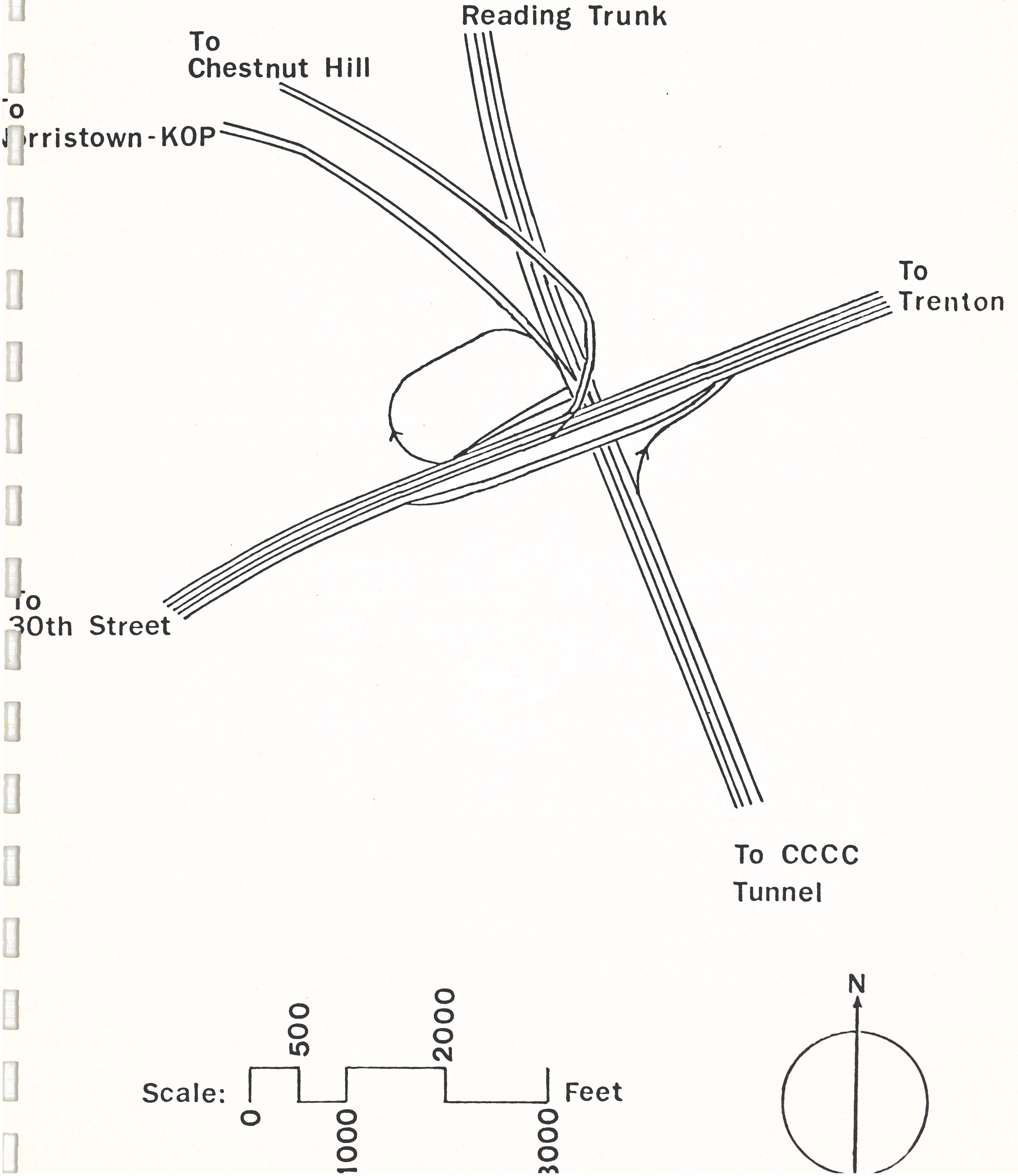
Line	Running Time (Minutes)	Average Speed (MPH)	Percentage Improvement in Running Times*
Chestnut Hill West	28.25	25.7	16.9
Trenton	45.9	41.2	17.9
Media	29.42	24.75	28.6
Wilmington	29.17	35.2	16.4
Norristown-King of Prussia	33.42	38.8	21.3**
Paoli	38.3	31.0	10.9
Fox Chase	22.5	30.9	10.0
Warminster	38.42	28.1	12.5
Lansdale	44.67	33.4	17.3
Doylestown	58.17	35.8	15.2
Airport	14.75	35.4	-
King of Prussia-Fort Washington	26.0	33.9	-

* over representative rush hour schedules
** to DeKalb Street

Upon calculation of the proper headways, lines were paired on opposite sides of the tunnel in such a way as to reduce over-capacity to a minimum and to respond to probable demand. Because current Penn Central lines on the west side tend to have heavier ridership to begin with, and in order

Figure 6-2

Recommended Track Layout at North Philadelphia



to reduce circuitous line-miles on the system, it was decided to operate the Trenton line over the Reading tracks south of North Philadelphia Station. In point of fact, a new station, North Broad Centre, will be created to integrate all lines in this area as much as possible. This will require new track construction to make the junction, but will result in better pairing and more sensible routing. (See Fig 6-2)

It was necessary to draw up general schedules for the two alternatives and in fact, to make a separate schedule for the commuter rail phase of Alternative I. In general terms these resulted in peak hour scheduling as shown in Figure 6-3.

Figure 6-3
Line Pairings and Vehicle Requirements

Modernized System Commuter Rail Phase
(Alternative I

Line Pairing	Average Headway (Minutes)	Cars per Train	Vehicle Requirements
Marcus Hook-Lansdale[1]	15	6	90
Marcus Hook-Doylestown	15	6	90
Paoli-Trenton	6.5	6	208
Chestnut Hill West-Norristown-KOP	9	6	110
Elwyn (stub)[2]	7.5	6	76
Elwyn-Warminster	15	6	76
Fox Chase-Airport	12	4	56
Total Requirements			706

Figure 6-3 (continued)

Modernized System
(Alternative I)[3]

Line Pairing	Average Headway (Minutes)	Cars per Train	Vehicle Requirements
Marcus Hook-Lansdale[1]	11	6	104
Marcus Hook-Doylestown[3]	11	6	118
Paoli-Trenton	4.5	6	276
Chestnut Hill West-Norristown-KPO	6.5	6	146
Elwyn (stub)[4]	6	6	84
Elwyn-Warminster	12	6	90
King of Prussia-Fort Washington	8.5	6	56
Fox Chase-Airport[3]	12	4	56
Total Requirements			930

Expanded System
(Alternative II)[3]

Marcus Hook-Lansdale	14	8	110
Marcus Hook-Doylestown[3]	14	8	130
Frazer-Paoli-Trenton	6.5	8	268
Chestnut Hill West-Norristown-KOP	8.75	8	148
Media-Lenni (stub)[5]	6.75	8	138
Media-Warminster	13.5	8	120
Trenton-King of Prussia[6] (Circum.)	7.5	8	194
Trenton-Chester City (Circum.)	15.0	8	156
Greater Northeast	8.0	4	46
Fox Chase-Airport[3]	12.0	4	38
Total Requirements			1,348

Notes: 1. Every other train from Marcus Hook operates to Lansdale and every other train continues beyond to Doylestown.

2. Average Headway on Elwyn (stub) is 7.5 minutes. Actually trains operate every 5 minutes between Elwyn and Penn Center with one in three going on to Warminster.

3. Trains to Doylestown and Fox Chase-Airport are considered commuter rail; all others are regional rail.

4. Average Headway: 6 minutes. Trains travel every 4 minutes to Penn Center, one in three goes to Warminster.

5. Average Headway: 6.75 minutes. Trains travel every 4.5 minutes to Penn Center, one in three goes to Warminster.

6. Average Headway: 7.5 minutes. Trains travel every 5 minutes between Trenton and King of Prussia. Every third train goes from Trenton to Chester City and back.

Guidelines for policy headways for off-peak service are as follows:

		Commuter Rail	Regional Rail
	Basic Crew	Engineer, Conductor	Engineer
	Hours of Operation	Policy Headways	
Weekday	6:30-9:30 a.m.	Frequent Service	Frequent Service
	9:30 a.m.-4:00 p.m.	Every 30 min.	Every 10 min.
	4:00-6:30 p.m.	Frequent	Frequent
	6:30-8:00 p.m.	Every 30 min.	Every 10 min.
	8:00 p.m.-midnight	Every Hour	Every 15 min.
Saturday	6:30-11:00 a.m.	Every 30 min.	Every 10 min.
	11:00 a.m.-4:00 p.m.	Every Hour	Every 20 min.
	4:00-6:00 p.m.	Every 30 min.	Every 10 min.
	6:00 p.m.-midnight	Every Hour	Every 20 min.
Sunday	7:00 a.m.-midnight	Every Hour	Every 20 min.

From observation of Figure 6-3, it is apparent that a few operational modifications were made to develop more efficient pairings and easier procedures. The Media-Elwyn line could not be matched with a line of equal ridership. But it was discovered that the Warminster line had roughly a third of the ridership of the Elwyn line and pairings were accomplished by making use of Penn Center's remaining stub-ended tracks. Thus, one in three trains goes on to Warminster, and the other two are reversed at Penn Center. Passengers wishing to travel beyond Penn Center can transfer there easily to any other line.

A similar arrangement exists with the Marcus Hook line, except that instead of stub-ending, trains alternate in destinations at the eastern end of the tunnel: half turn around at Lansdale, the others go all the way to Doylestown.

Lastly, substantial numbers of trains were saved by breaking the circumferential line of the expanded system (Alternative II) into two sections. For every three trains operating between Trenton and King of Prussia, only one travels beyond King of Prussia to Chester City which reflects the lower service requirements needs of this section. The team was also able to effect more efficient use of equipment through a "drop-back" crewing system in which crews arriving at the terminal are immediately relieved by a fresh crew which then takes over the train and drives it out. This requires only a minimal amount of time for the crews to change but saves the system the cost of idle equipment while the crew takes a break.

The Greater Northeast Philadelphia line will be served by trains operating between Holmesburg Junction on the Trenton line and Oxford Valley Mall on the Circumferential line. Passengers to and from Center City will be able to make a cross-platform connection at Holmesburg Junction.

Finally, one will notice that since almost all of the lines enter the center city tunnel, headways throughout the section between 30th Street and Penn Center will be very small indeed. It is estimated that average headways will be 2.69 minutes under the Modernized System and 2.79 under the Expanded System. This will necessitate automatic train operation (ATO) in order to insure smooth running. Likewise, the section of between Glenside and the proposed station at Keystone will be very heavily traveled with an average headway of 1.96 minutes. This section as well will require ATO.

6.9 Conclusion

This chapter has suggested ways to enhance intermodal connections. The team recommends a program of more innovative and agressive marketing, improved information systems and more attention to security in station design and in operations. The construction of high-level platforms at all stations will make better use of labor and should also speed up train operation. Redesign of vehicles with wider doors and narrower aisles will also help in this regard. The team ultimately suggests conversion to an automated fare collection system but recommends methods to discourage on-board fare payment until an automatic system is in place. Finally, the team has developed a new system of scheduling to make most efficient use of the Center City Commuter Connection.

REFERENCES--CHAPTER 6

[1] From Richard Grefe Associates, The Economic and Development Impacts of Terminating SEPTA's Regional Rail System in Philadelphia's Center City and the Region, (Citizen's Advisory Committee of the Southeastern Pennsylvania Transportation Authority, 1982), pp. 6, 10.

[2] Hoel, Lester., "Public Transit Passenger Security and Safety" in George E. Gray and Lester A. Hoel, Public Transportation: Planning, Operations and Management, (Englewood Cliffs, N.J.: Prentice-Hall, 1979), p. 469.

[3] Vuchic, Vukan R., et al., Train Crew Reduction for Increased Productivity of Rail Transit, University of Pennsylvania (unpublished), 1982, p. 66.

[4] Homburger, W.S., "Urban Transit" in Wolfgang S. Homburger, ed. Transportation and Traffic Engineering Handbook, (Englewood Cliffs, N.J.: Prentice-Hall, 1982), p. 191.

BIBLIOGRAPHY--CHAPTER 6

Gray, George E. and Lester A. Hoel. Public Transportation: Planning, Operations and Management. Englewood Cliffs, N.J.: Prentice-Hall, 1979.

Homburger, Wolfgang S., ed. Transportation and Traffic Engineering Handbook. Englewood Cliffs, N.J.: Prentice-Hall, 1982.

Richard Grefe Associates. The Economic and Development Impacts of Terminating SEPTA's Regional Rail System in Philadelphia's Center City and the Region. Citizen's Advisory Committee of the Southeastern Pennsylvania Transportation Authority, 1982.

Vuchic, Vukan R., et al. Train Crew Reduction for Increased Productivity of Rail Transit. University of Pennsylvania (unpublished), 1982.

CHAPTER 7

FARE STRUCTURE

by Aurelio Menendez

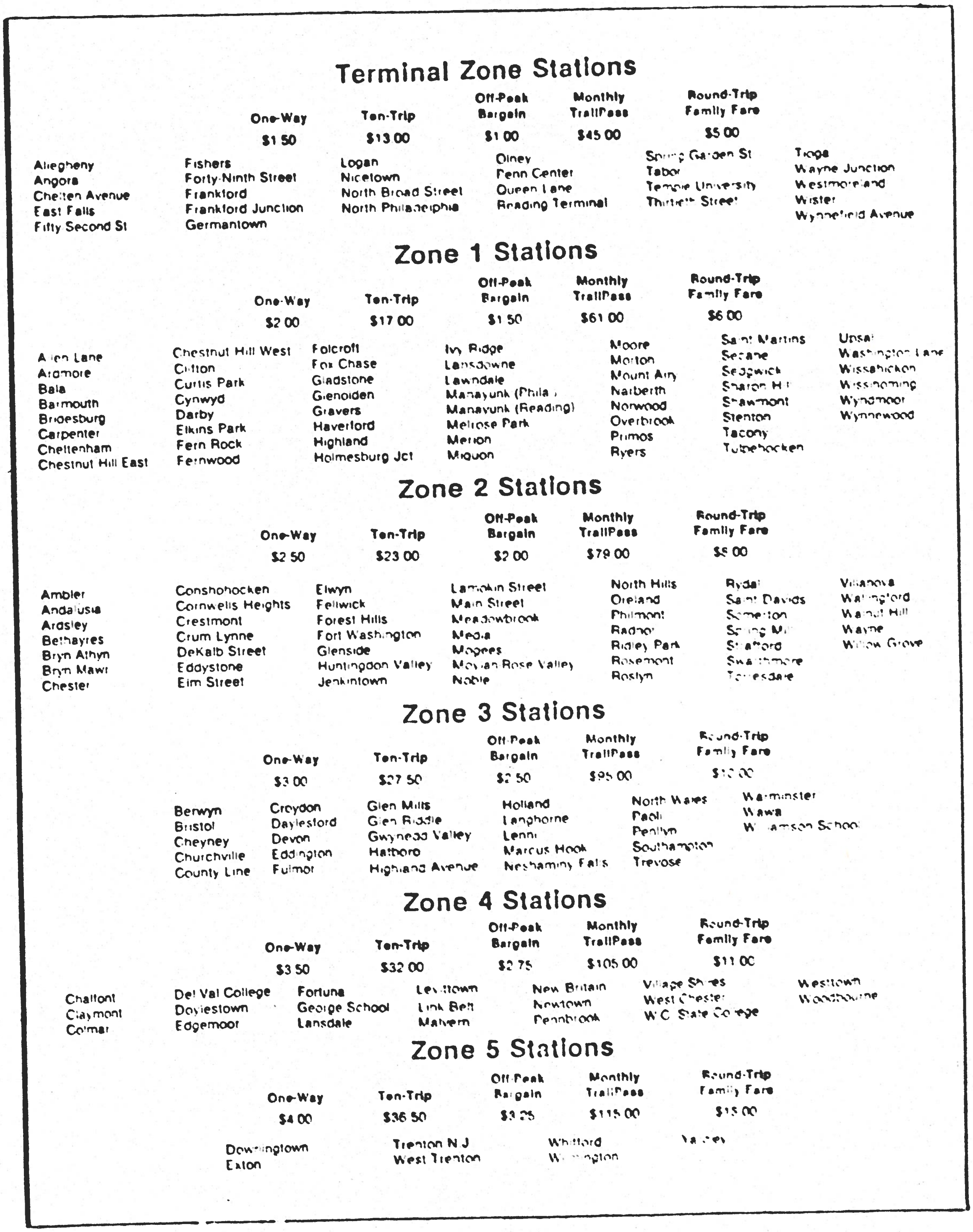
7.1 Existing Fare System

The present commuter rail system has a zonal fare system with six different zones: one terminal zone including the Philadelphia central business district, and five concentric zones beyond the terminal zone. The new fares which took effect in September 1982 are shown in Figure 7.1.

The fare system includes different types of fares depending on the time and amount of travel, and offers various types of reduced fares. There are one-way fares for peak-hours, reduced one-way fares for trips in off-peak periods, ten-trip strips, monthly passes (Trailpasses), and special round-trip family tariffs.

Trailpasses allow a month's worth of unlimited rides on SEPTA's commuter rail lines and also allows free rides on all SEPTA City Division lines, and one-zone trips on Suburban Division routes (zone charges additional). The monthly Trailpass is good on any commuter rail line between Philadelphia and any station in the zone for which it is purchased (and any intermediate stations) during the calendar month for which it is valid.

Figure 7.1 Existing Zone Fares



Terminal Zone Stations

One-Way	Ten-Trip	Off-Peak Bargain	Monthly TrailPass	Round-Trip Family Fare
$1.50	$13.00	$1.00	$45.00	$5.00

Allegheny
Angora
Chelten Avenue
East Falls
Fifty Second St
Fishers
Forty-Ninth Street
Frankford
Frankford Junction
Germantown
Logan
Nicetown
North Broad Street
North Philadelphia
Olney
Penn Center
Queen Lane
Reading Terminal
Spring Garden St
Tabor
Temple University
Thirtieth Street
Tioga
Wayne Junction
Westmoreland
Wister
Wynnefield Avenue

Zone 1 Stations

One-Way	Ten-Trip	Off-Peak Bargain	Monthly TrailPass	Round-Trip Family Fare
$2.00	$17.00	$1.50	$61.00	$6.00

Allen Lane
Ardmore
Bala
Barmouth
Bridesburg
Carpenter
Cheltenham
Chestnut Hill East
Chestnut Hill West
Clifton
Curtis Park
Cynwyd
Darby
Elkins Park
Fern Rock
Fernwood
Folcroft
Fox Chase
Gladstone
Glenolden
Gravers
Haverford
Highland
Holmesburg Jct
Ivy Ridge
Lansdowne
Lawndale
Manayunk (Phila.)
Manayunk (Reading)
Melrose Park
Merion
Miquon
Moore
Morton
Mount Airy
Narberth
Norwood
Overbrook
Primos
Ryers
Saint Martins
Secane
Sedgwick
Sharon Hill
Shawmont
Stenton
Tacony
Tulpehocken
Upsal
Washington Lane
Wissahickon
Wissinoming
Wyndmoor
Wynnewood

Zone 2 Stations

One-Way	Ten-Trip	Off-Peak Bargain	Monthly TrailPass	Round-Trip Family Fare
$2.50	$23.00	$2.00	$79.00	$5.00

Ambler
Andalusia
Ardsley
Bethayres
Bryn Athyn
Bryn Mawr
Chester
Conshohocken
Cornwells Heights
Crestmont
Crum Lynne
DeKalb Street
Eddystone
Elm Street
Elwyn
Fellwick
Forest Hills
Fort Washington
Glenside
Huntingdon Valley
Jenkintown
Lamokin Street
Main Street
Meadowbrook
Media
Mogees
Moylan-Rose Valley
Noble
North Hills
Oreland
Philmont
Radnor
Ridley Park
Rosemont
Roslyn
Rydal
Saint Davids
Somerton
Spring Mill
Strafford
Swarthmore
Torresdale
Villanova
Wallingford
Walnut Hill
Wayne
Willow Grove

Zone 3 Stations

One-Way	Ten-Trip	Off-Peak Bargain	Monthly TrailPass	Round-Trip Family Fare
$3.00	$27.50	$2.50	$95.00	$10.00

Berwyn
Bristol
Cheyney
Churchville
County Line
Croydon
Daylesford
Devon
Eddington
Fulmor
Glen Mills
Glen Riddle
Gwynedd Valley
Hatboro
Highland Avenue
Holland
Langhorne
Lenni
Marcus Hook
Neshaminy Falls
North Wales
Paoli
Penllyn
Southampton
Trevose
Warminster
Wawa
Williamson School

Zone 4 Stations

One-Way	Ten-Trip	Off-Peak Bargain	Monthly TrailPass	Round-Trip Family Fare
$3.50	$32.00	$2.75	$105.00	$11.00

Chalfont
Claymont
Colmar
Del Val College
Doylestown
Edgemoor
Fortuna
George School
Lansdale
Levittown
Link Belt
Malvern
New Britain
Newtown
Pennbrook
Village Shires
West Chester
W.C. State College
Westtown
Woodbourne

Zone 5 Stations

One-Way	Ten-Trip	Off-Peak Bargain	Monthly TrailPass	Round-Trip Family Fare
$4.00	$36.50	$3.25	$115.00	$15.00

Downingtown
Exton
Trenton N.J.
West Trenton
Whitford
Wilmington
Yardley

Source: SEPTA Trailpass brochure, August, 198[illegible].

The cost of a ride using a ticket from a ten-trip strip is between 8 and 15 percent cheaper than using a one-way ticket. Off-peak bargain tickets are between 16 percent and 33 percent cheaper compared to the peak-hour fare.

Family fares are good for a round-trip to terminal zone stations for a party of up to five people. At least one person, but not more than two, must be eighteen years of age or older, and, if one of the adults has a valid monthly pass, the family receives a 50 percent discount on the cost of the family fare ticket. Family fare tickets are not good on peak service trains, i.e. those scheduled to arrive at Penn Center, 30th Street Station or Reading Terminal between 6:00 a.m. and 9:30 a.m. or depart from the same stations between 4:00 p.m. and 6:00 p.m. on weekdays.

Senior citizens can ride the commuter rail lines free in Pennsylvania during off-peak hours. To receive the free fare, senior citizens must present a special rail coupon that is available upon presentation of a valid identification card. The only exception for the free fare is for stations outside of Pennsylvania (Trenton, West Trenton, and Delaware stations). Senior citizens must pay full fare to these stations, as well as on all peak-hour trains. Finally, handicapped riders pay one-half of the one-way peak fare during off-peak hours, but they must pay regular fares on peak service trains.

7.2 Evaluation of Existing Fare System

A zone fare system is the easiest way to charge according to the distance traveled. The two main advantages of this type of fare structure are first, that it differentiates between short and long trips, making the system more equitable than with a flat fare; and second, higher fares may be charged for longer trips, making the system more efficient. However, zonal fares may be less than perfectly equitable, because short trips crossing zone lines cost more than longer trips taken entirely within one zone.

The zonal fare system in the Philadelphia region does not correspond very well with the distance traveled. Generally, commuter rail lines to the south and west cost more on a per-mile basis than commuter rail lines to the north and east. While absolute cost-per-distance equity is sometimes not desirable, a more equitable fare structure may be achieved for the Philadelphia rail system.

Another disadvantage of the present zonal fare system is its poor financial performance. It is necessary to provide equipment and labor to deal with peak period demand, while price policies do not establish sharp differentials between peak and off-peak fares. A sharper differential between these two types of fares may contribute to improve system efficiency by balancing the demand throughout the day. Efficiency may also be improved by reducing the labor costs involved in fare collection through installing an automatic fare collection system.

Besides reducing the operating costs, automatic fare collection systems allow for a more sophisticated, equitable and efficient fare system and, at the same time, provide for a greater convenience to passengers. Vending machines accepting coins plus one- and five-dollar bills, supplemented by bill-changing machines, can make it quite easy to purchase the tickets from machines. Furthermore, ticket windows are often closed, but vending machines are always on duty.

As to the different types of fares, the present system has an adequate number of possibilities. Regular one-way tickets, Trailpasses, ten-trip tickets, off-peak bargain tickets, and family fares, along with the reduced fares for the elderly and handicapped provide a wide selection of tickets depending on the type of rider. However, some improvements can be made to the system in this respect.

An improved fare structure must take advantage of the differences in fare elasticities across transit markets. This can be done by making different fare levels in the following order of decreasing cost:

- Infrequent peak-hour user
- Regular peak-hour user
- Infrequent off-peak hour user
- Regular off-peak hour user

The normal single peak-hour fare would be the fare level for the first group of users. Monthly Trailpasses and a new weekly version replacing the current ten-trip ticket would allow for cheaper fares to regular peak-hour users, depending on the frequency of use. The off-peak hour bargain ticket would apply to the third group of passengers, while other Trailpasses, valid during off-peak hours only, could be used by regular off-peak riders.

In addition to the special fares for family groups and those for the elderly and handicapped population, the system should include reduced fares for children and students. Such a policy may benefit the transit agency in the long run, since it encourages the habit of using public transit early in life, a habit that often continues beyond the "reduced fare" years.

Shopper fares are another type of discounted fares which may encourage ridership in some sections of the system. These fares should apply only in off-peak hours and might be subsidized by shopping centers since they benefit from the reduction in parking spaces they must supply.

Finally the radial pattern of the existing network, the orientation of the trips to Philadelphia's CBD, and the consequent influence in the fare program must also be mentioned. If a more comprehensive network, including both radial and circumferential lines is to be implemented, this pattern must be reflected in the fare policy.

7.3 Proposed Fare System

Taking into consideration all the aforementioned aspects of transit fares, the following fare plan is proposed for both Alternative I and Alternative II.

The fare structure would be graduated, charging the users according to the length of the ride. The system will feature an automatic fare collection system which will make it possible to charge depending on the distance traveled, the period of the day, the type of user, etc. (see Chapter 2 for technological details). The purposes of this system are to make the fare structure more equitable, and at the same time, to reduce the cost of collecting the fares. An automatic fare collection system will allow the easy application of what would otherwise be a complicated fare structure.

The one-way peak hour ticket would consist of a minimum base fare for trips among neighboring stations, and a linear decreasing marginal cost according to distance.

From Figure 7-2, the additional cost per mile can be easily calculated:

$$\frac{C_1 - C_2}{L - 1} \qquad \frac{C_4 - C}{1 - 1}$$

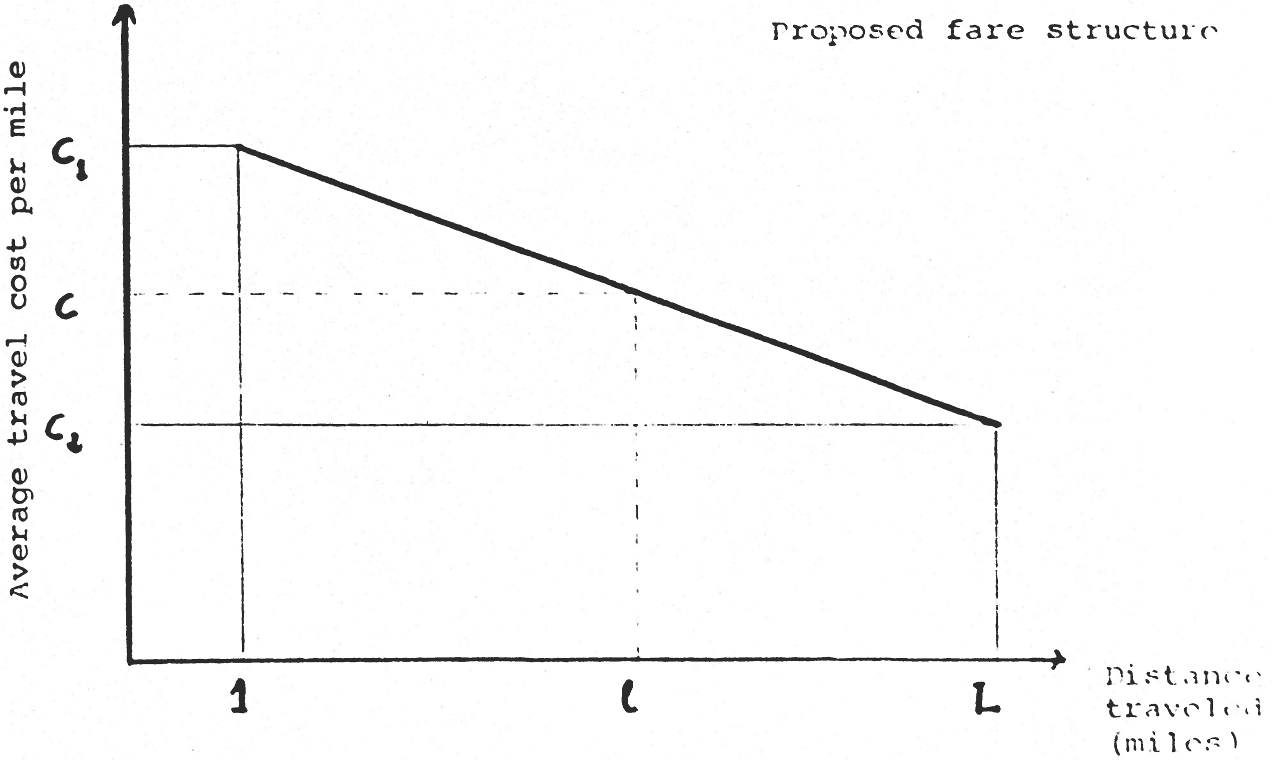


Figure 7.2

Proposed fare structure

Then,

$$c = c_1 - \frac{(c_1 - c_2)\ (l - 1)}{L - 1}$$

and the total fare for a passenger riding between two stations located at l distance from one other would be:

$$C = B + c\ l = B + c_1 - \frac{(c_1 - c_2)\ (l - 1)}{L - 1} \times l$$

where B is the base fare; l, the distance traveled; c, the average cost per mile for the distance l; and c_1 and c_2 the established cost per mile for distances of 1 mile and L miles, respectively. This cost would be rounded up to the nearest multiple of 5 cents.

For instance, if the base fare were 75¢, and the mileage charge is 40¢ for a one-mile trip, decreasing at a constant rate until reaching 10¢ per mile for a trip of 50 miles or more, the total fare for a ride from 30th Street to Paoli, a distance of 19.1 miles, would be:

$$C = 0.75 + ((0.20 - \frac{(0.20 - 0.10)\ (19.1 - 1)}{50 - 1} \times 19.1)$$

$$C = 3.86, \text{ rounded up to } \$3.90$$

Besides this fare for peak periods, there would be a reduced fare for off-peak hour passengers with a value between 30 percent and 40 percent lower than the peak-hour fare. Monthly and weekly passes would permit regular riders to make cheaper trips in both peak and off-peak periods. Peak-hour passes would allow to ride the system in off-peak periods as well. However, off peak passes would only allow non-rush hour travel. The cost per ride (assuming two rides per day for the passes) should decrease for each of the four types of tickets (one-way peak fare, peak period passes, one-way off-peak fare, and off-peak passes). Weekly and monthly Trailpasses, like the one-way tickets, would be sold on a station-to-station basis, and their prices would also be proportional to the distance traveled, as indicated in

Figure 7-2. Weekly passes could be purchased at vending machines located at all stations. Monthly passes, in turn, would be sold by mail, at Center City stations, and at some other important stations where retaining ticket windows could be justified.

Mileage between stations should be calculated via the shortest possible route, regardless of how the passenger in fact chooses to travel from origin to destination. Since the Chestnut Hill West line intersects the Reading trunk at North Broad Centre, passengers between Center City and points on the Chestnut Hill West line should be charged for the shorter Reading mileage south of North Broad Centre.

Center City should be treated as a single station, with tickets being equally valid at 30th Street, Penn Center and Market East. Mileage would be calculated only from 30th Street or Market East, depending on which Center City station is closer to the outlying station in question. Thus, one could travel from Paoli to Market East for the cost of a ride to 30th Street, or from Jenkintown to 30th Street for the price of a trip to Market East. Fares for local travel between 30th Street, Penn Center and Market East, on the other hand, should be high enough to encourage such local riders to use City Transit Division services instead.

Elderly and handicapped people will continue to have the same privileges offered by the existing system, and the same goes for family groups. In addition, discounted fares for school children and shopping trips will be also available. The latter type would allow to make cheaper off-peak period trips to major shopping centers.

As to the transfers, the vending machines would accept valid transfers from other transit modes (either punch-coded as in Montreal or magnetically coded as in Atlanta), and in the rail stations, vending machines in the turnstiles themselves would provide transfer tickets upon payment of the standard transfer charge. Monthly and weekly passes would allow use of all City Transit Division services and the first suburban zone free of charge, as the Trailpasses do today. The integration of the rail system with the remainder of the region's transit system is very important in achieving higher levels of efficiency and improving public transit service in the Delaware Valley.

At most stations, excess fares could be handled from the system's central control, using call-for-aid phones like those on PATCO's Lindenwold Line. At a few stations (Center City, King of Prussia) Washington Metro-style Addfare machines might be used, but their number should be strictly limited because their capital cost is around two orders of magnitude greater. (PATCO estimates a call-for-aid phone at about $200, against a $25,000 price for Addfare machines.)

7.4 Fare Revenues

Fares are the major source of revenue for transit agencies. Therefore, they have a great influence on the level of subsidy that the agency requires in order to cover its operating costs. Revenue, along with the ridership level, is one of the most important indicators of transit system performance. These two indexes, influenced by the specific characteristics of the system and its users, may not move in the same direction or at the same rate, since fare levels have a great impact on people's attitudes toward transit services. Transit demand elasticities are an important tool to help transit operators estimate passenger response to fare and service variations. Disaggregate demand elasticities can provide operators with indications of how ridership and revenue can be increased by manipulating both fare and service levels.

Figure 7.3 shows the ridership and revenue figures for the existing system during the fiscal years 1980, 1981 and 1982. From these figures, the average trip length and the cost charged per passenger mile were calculated.

For the proposed alternatives, the following assumptions have been made:

- An increase in the average trip length of 10 percent for the first stage commuter rail service of the modernized system, of 15 percent for the final stage

Figure 7-3

Current System Ridership and Revenue

Fiscal Years	1980	1981	1982
1. Annual ridership (thousand pass)	32,280	28,604	24,114
2. Annual passenger-miles (thousands)	396,198	341,308	271,023
3. Annual revenue (thousands dollars)	37,422	46,583	41,607
4. Average trip length (2 ÷ 1) (miles)	12.27	11.93	11.24
5. Fare per pass-mile (3 ÷ 2) (dollars)	0.0945	0.1365	0.1537

Source: Telephone conversation with SEPTA official

of this system (Alternative I), and of 20 percent for the expanded system (Alternative II).

- An increase of 5 percent in the fare charged per passenger-mile for all the systems. The dramatic improvement in the level of service of the rail system in the two alternatives allows for this slight increase without hurting ridership.

Taking all these aspects into consideration, operating and financial vistal statistics have been computed and are shown in Figure 7-4. The percentage of the operating costs covered by revenues is 58.0 percent for the first stage of the Modernized System, increasing to 68.6 percent for the regional rail phase. The Expanded System shows nearly 80 percent of the operating expenses coming from the farebox.

Figure 7-4

Operating Costs, Modernized and Expanded Systems

	Alternative I Modernized System		Alternative II
	Commuter Rail Phase	Regional Rail Phase	Expanded System
Operating Costs ($ thousand)	153,225.00	201,316.50	283,111.50
Daily ridership (passengers)	162,000	240,500	377,400
Annual ridership (thousand pass.)	44,550	66,138	103,785
Average trip length (miles)	12.36	12.93	13.49
Operating revenue per passenger-mile (dollars)	0.1614	0.1614	0.1614
Annual pass-miles (thousands)	550,640	885,160	1,400,060
Fare revenues ($ thousand)	88,889.49	138,048.14	226,011.63
Percentage of operating costs covered by revenues	58.0	68.6	79.8

BIBLIOGRAPHY--CHAPTER 7

Delaware Valley regional Planning Commission. Commuter Rail Passenger Survey: Fall 1982. DVRPC, February 1983.

Gray, George E., and Hoel, Lester A. Public Transportation: Planning, Operations, and Management. Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1981.

Mayworm, Lago, and McEnroe. Patronage Impacts of Changes in Transit Fares and Services. Report prepared for the Office of Service and Methods Demonstrations, Urban Mass Transportation Administration, September 1980.

Simpson and Curtin. Fare Structure Analysis and Alternative Strategies. Technical memorandum prepared for the SEPTA Management Study Steering Committee and the Delaware Valley Regional Planning Commission, July 1977.

Transportation Research Board. Report Number 799.

Urban Mass Transportation Administration and Delaware River Port Authority. Alternatives Analysis and Draft Environmental Impact Statement for the Lindenwold-Berlin-Atco Corridor in Camden County, New Jersey, October 1982.

Information directly gathered through telephone calls from SEPTA and PATCO transportation authorities, March and April 1983.

CHAPTER 8

RIDERSHIP

by Scott Gibbons

8.1 Purpose and Scope

Ridership estimates are of major importance to this study. Ridership figures for a future date are highly dependent on population and employment projections for that date, in this case the year 2000. This study team had initially considered using the DVRPC Regional Development Guide (RDG),[1] but after examining the New Jersey Development Guide[2] and Travel Forecasts and Evaluation of Year 2000 Alternative Transportation Plan II (FOR),[3] which contained excerpts from the 1980 U.S. Census,[4] it was concluded that the RDG was not an adequate basis from which to generate ridership estimates for the year 2000. In addition, the estimates for FOR were considered somewhat too pessimistic, primarily because it did not consider the 1980 Census, but relied on the preliminary figures for 1977 as did the RDG.[5] Trends based on the 1977 figures could not be used with confidence in light of the updated 1980 statistics (see Figures 8-1 and 8-2 below). It was concluded that altogether new population and employment projections would be required in order to project future rail ridership.

Figure 8-1

Population Profile of the Study Area

Population	1970	1977	1980	2000(RDG)	2000(FOR)
Bucks	417	474	479	550	540
Chester	278	299	317	325	330
Delaware	603	584	555	676	590
Montgomery	624	633	644	780	670
Philadelphia	1950	1772	1688	1961	1780
Mercer	304	323	308	380	360
Del. Valley	5128	5124	5025	5940	5465

Source: RDG, FOR, U.S. Census 1977, 1980

Figure 8-2

Employment Profile of the Study Area

Employment	1970	1977	1980	2000(RDG)	2000(FOR)
Bucks	131	153	186	170	175
Chester	108	110	139	120	125
Delaware	181	182	201	226	198
Montgomery	303	321	372	370	367
Philadelphia	1014	880	849	1264	935
Mercer	154	160	184	189	195
Del. Valley	2227	2141	2315	2743	2409

Source: RDG, FOR, U.S. Census 1977, 1980

8.1 Data Analysis

Since the emphasis was to forecast and assess, rather than determine the future employment and population figures from policy, it was observed that the Delaware Valley has not been a growth area despite the fact that some growth dynamics were present in all counties except Delaware and

Philadelphia, the pattern of employment and population growth was one of redistribution from Philadelphia and Delaware to Mercer and the other Pennsylvania counties. The region did experience a small net loss in population but not in employment. This resulted in a small reduction in the population/employment ratio from 2.29 to 2.17 between 1970 and 1980. The population/employment ratio is a major factor in these projections. It is interesting to note that RDG adopts the 2.17 and FOR the 2.3 figure.

The reduction in the p/e ratio can be explained by various factors, but the most likely are that some jobs in the Delaware Valley are held by commuters from outside the planning region, and that an increased percent of the population is working due to the entry of large numbers of women into the workforce in the 1970's as a result of strong inflation. No data showed that the impact of the first factor was significant, but a number of sources, including DVRPC, mentioned the second factor. The study team assumed that an equilibrium was maintained in the region, in which certain demographic changes would take place, altering residential location and employment characteristics.[6]

8.2 First Round Ridership Model

The initial calculations were based on a model of intraregional shifts of population and employment shares observed between 1967 and 1980, with totals for the region based on an average of DVRPC FOR, RDG, and extension of 1970-80 trends. This formula was designed to predict the actual percentage share of employment and population that each county would have in the year 2000, by projecting the observed change in percentage share of each county between 1967 and 1980 to the year 2000 estimated totals.[7]

This formula's purpose was to generate raw, first round ridership figures from which to begin the rail system's planning process in earnest. Employment and population figures were neither adjusted to compensate for unequal growth, nor were there any limits placed on the growth or decline of any county. The 1977 DVRPC Total Person Trip Zonal Matrix[8] provided the trip generation totals for each county, which were applied to the population to arrive at a trip generation rate for each county. After this, the estimated population of each county was multiplied by this rate. The ratios between the 1977 and year 2000 individual county total person trips were calculated and multiplied across the 1977 matrix to produce adjusted zonal figures which were used to help determine alignments.

8.3 Construction of Final Ridership Model

8.3.1 Methodology

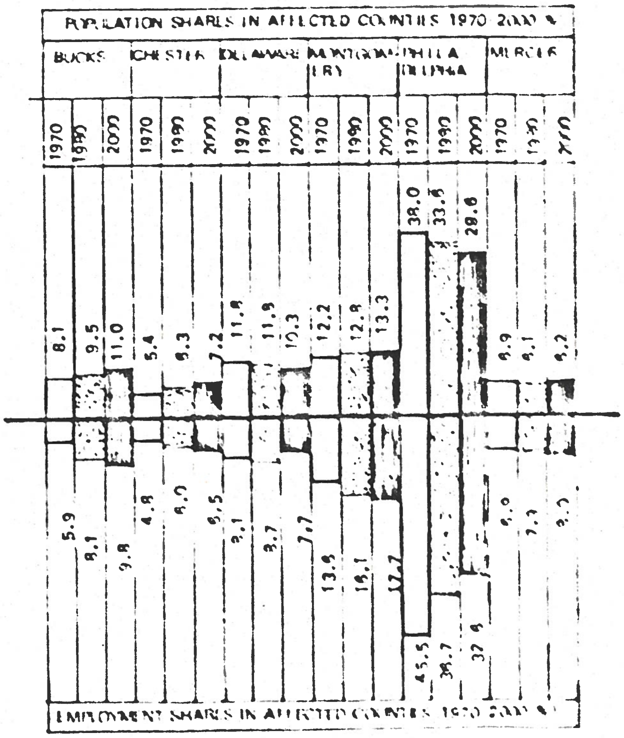
After determining the alignments, the need for more realistic and justified population, employment and ridership figures became evident. Because FOR and RDG were not calculated from the 1980 Census results, it was decided that they should not be used as bases for calculations. Bearing in mind the flux of the region and its enormous change from 1970-80, it was decided that the most reliable basis from which to speculate on the region's future makeup would be the Census results from 1970 to 1980. Using the growth and decline figures for employment and population on an annual basis and projecting them to the year 2000 resulted in regional growth with the population/employment ratio 1.2 and a decimated Philadelphia County with a 1.2 million population, both of which seemed untenable.

8.3.2 Model Adjustment Assumptions

It was therefore decided to adopt several key assumptions. The first was that the p/e ratio would remain nearly the same, dropping from the 1980 rate of 2.17 to 2.1 in the year 2000. This change is based on a national trend toward a higher population workforce percentage due to demographic and economic changes. Secondly, it was assumed that in a stabilized region such as the Delaware Valley, population would tend to constrain employment opportunities in the region. This may be a controversial assumption, but whereas growth areas may find employment opportunities determining population size, the dynamics for any so-called "declining" or "mature" region indicate just the opposite.

The last two assumptions are also very important. It was judged that the region would not decline more than the same percentage of the Philadelphia and Delaware County loss that was not absorbed by the other seven counties in the Delaware Valley 1970-80. Since this was small and because of the belief that the region is stabilizing, no regional loss was projected. Instead, the projected losses of Philadelphia and Delaware Counties for the year 2000 were adjusted downward to maintain regional equilibrium. The result was a 240,000 instead of a 310,000 loss for the two, based on their earlier percentage of regional loss. This 240,000 was distributed to the other seven counties based on their 1980 regional population shares (see Figure 8-3).

Figure 8-3: Population and Employment Shares in Affected Counties



Source: DVRPC Revised 1990 and 2000 Population and Employment Forecasts (preliminary unpublished). Self Generated [illegible]

8.3.3 Summary

The assumptions made limited employment to the 2.1 p/e ratio based on projection of only population trends. Employment figures were not forecast for counties as were population estimates, but were left at the regional level. Unpublished preliminary DVRPC year 2000 county forecasts for county employment were used for reference.[9] The change in population figures from 1980 was due to a distribution of projected losses for Philadelphia and Delaware Counties to the other counties based on their 1980 population shares.

8.4 Person Rail Trip Estimates

Trip generation rates for person trips varied considerably in 1977 among the suburban counties, with the highest being in Montgomery County where the rate was 3.2 trips per person. In order to account for improved transportation accessibility, an average of Bucks, Chester, Montgomery and Mercer Counties' trip generation rates was taken as a base for the year 2000 in Bucks, Chester, Delaware and Mercer Counties. A slight increase in the rate for Montgomery County to 3.3 and for Philadelphia County to 1.9 was projected. After multiplying this new rate with the year 2000 populations for each county, total person trips were obtained which were adjusted to the matrix to determine zonal trips.

After these figures were obtained, they were multiplied by the Home-Based-Work (HBW) trip factor of 0.29. These HBW trips were then multiplied by a capture rate of 0.22 for modernized regional rail and 0.15 for conventional but improved commuter rail ridership. The regional rail "capture rate" of 0.22, it will be noted, is more cautious than the actual BART ratio of 0.27. The 0.15 rate was roughly equidistant from the regional rail and the existing commuter rail rate of 0.08 in this region.

Once the Alternative I and II alignments were formalized, an estimated 5 mile radius was drawn around each alignment (allowances were made for overlapping) and the covered percentage of each zone was estimated and multiplied by the zone total (rail HBW). The resulting figures indicate potential trips both to and from the suburban zones (i.e. including reverse commuting). They indicate that lines such as Elwyn, Paoli, and Chestnut Hill are presently rather well served, with somewhat limited potential for increases. The other lines, however, show great opportunity for ridership increases (see Appendix IV).

For logistical reasons, upgrading of alignments and service would take at least until the year 2000 to complete, and therefore it would be unreasonable to expect more than a doubling of ridership for Alternative I. This is in part due to the time necessary for people to become sufficiently acquainted with the new system so as to generate the 100 percent increase. For the Center City-Norristown line a growth of 200 percent is used as a limiting factor. This larger increase is due primarily to the link with King of Prussia. The study team feels that these figures are very attainable if introduction of the proposed service improvements is properly timed. The construction of the King of Prussia link is likely to have unanticipated effects on the entire system, but will certainly boost its use.

8.4.1 Final Ridership Totals

For the first phase of Alternative I using improved commuter rail service, ridership is estimated to be 162,000, while in the second phase where substantial regional rail service is employed, it is 240,500. In Alternative II the circumferential line is estimated to produce 95,000 riders above and beyond those on Alternative I lines. The increased accessibility resulting for the whole system is estimated by a factor of 5 percent multiplied by ridership on all lines, including the circumferential. This results in a figure of 119,000 for the circumferential lines and a total for Alternative II of 377,000. The breakdown of these figures into individual lines is found in Appendix IV.

8.5 Demographic Factors and the System

It is especially important to stress the relationship of integrating mini-cities planning with the Alternative II system with regard to demographic changes in the region. In the years 2000 and 2020, the region's population will be composed of many more senior citizens than today. There will be more households as their size shrinks and fewer households are of the "traditional" family type. It is likely that households will occupy less square footage and will be increasingly composed of higher density clustered units. The mini-cities plan will channel this pattern into locations well served by transit.

The trend toward an older population will significantly increase the transit ridership of the years 2000 and 2020, as the elderly are less likely to own and use automobiles than younger age groups. Two issues arise in connection with this. The first is that the elderly may leave for warmer climates. This issue will depend less on the general climate of the Delaware Valley than on the affluence of the region and the overall quality of life offered here. The second is that they may want to go to different places and at different times than the present commuter rail system permits. These individuals will likely be today's suburban residents who use commuter rail only for work trips. Unlike Alternative I, Alternative II addresses this issue by allowing riders to easily reach a much wider variety of destinations by rail.

8.6 Scenario for Years 2000 and 2020

Alternative II represents an attempt to improve this region's desirability. The Northeastern United States as a whole is likely to continue its decline in the period 1980-

2020, but the results need not necessarily be distributive. The Northeast and the Delaware Valley in particular enjoy irreplacable amenities and infrastructure, and therefore will retain a diverse core population. Should the Delaware Valley implement Alternative II, the study team believes that the region will retain its 1980 population as well as gain residents from less accessible, and hence less desirable regions in the Northeast. In the absence of Alternative II, even with the vastly improved Alternative I, it is unlikely that past trends will be reversed, implying population decline by the year 2020. Alternative II seeks to accommodate past trends, adapt to ones in process and anticipate and plan for future ones, including dynamic mini-city development.

8.7 Conclusion

The study team is convinced of the feasibility of adapting the commuter rail system to changed needs. Emphasizing proper multi-purpose center development and effectively linking them together will strengthen not only suburban shopping malls but also Center City Philadelphia, through increasing the ease of access to all. The proposed system will be very effective. Fare structures and service planning should emphasize public transit's new role, and help acquaint the public with the new system, thus encouraging its use. The data indicate that a vast untapped clientele exists, even using just conventional commuter rail with innovative marketing techniques. If modern technology and a flexible fare system are added, the various parts of the region will be vastly more accessible to residents and visitors alike. The multipurpose centers/regional rail combination, with its visible employment dynamics may even be able to increase the region's population vis-a-vis its Northeastern competitors. If so, it would be the forerunner among American cities in the new millenium.

REFERENCES--CHAPTER 8

[1] *Regional Development Guide for the Delaware Valley*, Philadelphia DVRPC, 1982.

[2] *State Development Guide Plan Revised Draft*, Trenton, N.J. Department of Community Affairs, Division of Planning, 1980.

[3] *Travel Forecasts and Evaluation of Year 2000 Alternative Transportation Plan II*, Philadelphia DVRPC, 1949.

[4] *Census of the United States 1980*, Washington, U.S. Department of Commerce, Bureau of the Census, 1982.

[5] *Census of the United States, 1977*, Washington, U.S. Department of Commerce, Bureau of the Census, 1979.

[6] *Regional Development Guide*.

[7] Self-generated from ridership task group.

[8] 1977 (Total) Person Trips (Zonal Matrix), Philadelphia DVRPC, 1980.

[9] *DVRPC Revised 1990 and 2000 Population and Employment Forecasts* (preliminary, unpublished).

CHAPTER 9

COST ANALYSIS

by Joseph Augustyn (Capital Costs)
and Aurelio Menendez (Operating Costs)

9.1 Introduction

9.1.1 Purpose and Scope

The primary objective of the project's cost report is to develop up-to-date estimates of the various cost elements which will be encountered in the final design, construction, operation and maintenance of the proposed regional rail system.

This study intends to develop preliminary cost information which will help the planners and policy makers involved in the preliminary evaluation and selection of rail transportation alternatives within the Philadelphia region.

9.1.2 Definition of Systems

As previously described, the proposed transit system is separated into two phases: the Modernized System and the Expanded System. The Modernized System will involve both commuter rail and regional rail, while the Expanded System will include both of these and possibly people-movers. To be definitive in cost preparation, these systems are defined as follows as they relate to this study:

Regional Rail (RR). High frequency, high capacity rail system operating on exclusive right-of-way, whether at grade or on an elevated structure. The vehicles are electrically powered by overhead catenary and may operate in trains of up to eight cars. High level platforms and multiple door access on the vehicles are supplied. Fare collection is made through an automatic revenue collection system.

Commuter Rail (CR). Like Regional Rail, except moderate frequency and possibility of grade crossings so long as this does not interfere with station operations.

People-Mover (PM). Small to medium capacity guided vehicles, operating automatically on non-rail guideways to connect rail stations with other activity centers.

9.1.3 Capital Costs

Capital costs were generated using unit costs of rail transit systems in several North American cities, with particular emphasis on cost projections for the proposed PATCO High Speed Line extensions. In addition, unit costs were also obtained from contractor bids for improving the existing Philadelphia system, from private transit manufacturers, and from various public transit agencies. All capital cost estimates are indexed to 1982 Dollars. Unit costs were obtained from these sources:

1. Gannet, Flemming, Cordry and Carpenter, Inc., Ballante, Clauss, Miller and Nolland, Inc., Technical Studies Report for the Mass Transportation Development Program

of the Delaware River Port Authority: Volume 5, Economic Evaluation of Transportation Improvements, PATCO, December 1975.

2. Vuchic, Vuchan R., Urban Public Transportation Systems and Technology, Englewood Cliffs, N.J., Prentice-Hall, 1981.

3. Robert Snow Means Co., Inc., Building Construction Cost Data 1983, Robert Snow Means Co., Inc., 1982.

4. Thomas K. Dyer, Inc., Rail Transit System Cost Study, UMTA-MA-06-0025-76-3, January 1976.

5. American Public Transit Association, Transit Fact Book 1981, APTA Statistical Department, Washington, D. C., 1981.

6. Pushkarev, Boris, Urban Rail in America, Bloomington, IN, Indiana University Press, 1982.

7. American Standard Inc., Union Switch & Signal Division, Swissvale, PA. Information supplied via telephone communication.

8. Anaconda-Ericsson, Inc., Wire and Cable Division, Indianapolis, IN. Information supplied via telephone communication.

9.1.4 Operating Costs

Estimated annual operating and maintenance costs have been prepared for each alternative on the basis of current wage and price levels in the southeastern Pennsylvania economy. The cost estimates have also been developed with reference to local commercial and operating practices, and physical conditions within the different corridors. In each case, a specific operating plan has been developed to accommodate the expected passenger volumes. The estimates are in 1982 dollars (see Bibliography).

9.2 System Capital Costs Defined

9.2.1 General

The construction of a modernized or expanded regional rail system for the Philadelphia region involves a multitude of choices as to route location, system size, capacity requirements, quality of service, and degree of technological sophistication. A wide variation was found in the costs of improvements for the various transit systems examined. These differences were due to variations in standards, local conditions and contract terms. Capital unit costs in this report are therefore based on representative improvements from several systems. All costs are indexed to 1982, based on Means Construction Cost Data. The unit prices presented herein should be used with discretion.

9.2.2 Development Costs

Since the proposed regional rail system for the Delaware Valley uses "off the shelf" technology, development costs will be minimal. Development costs will, therefore, not be included in capital cost estimates.

9.2.3 Route Construction

Route construction as defined herein involves grading and drainage work, removing rocks, trees, debris and existing buildings and pavement. Since existing railroad right-of-way provides for almost all of the selected alignments, little costs are anticipated for route construction. These costs are, however, included in the figures. Costs per mile for route construction is $75,000 based on Means construction cost estimates.

9.2.4 Right-of-Way and Land Acquisition

Existing rights-of-way will generally be used. Additional right-of-way will, however, be needed for track construction where existing rights-of-way accommodate only a single track. Land acquisition will be needed for station expansion and new parking lots. Joint development land acquisition is not included. Unit costs for vacant property adjacent to regional rail stations is averaged at $50,000 per acre. Improved property adjacent to stations is averaged at $150,000 per acre. These estimates also include legal, survey and brokerage costs. Unit prices are based on regional tax assessor estimates of market value.

9.2.5 Guideways

Guideway improvements include base and ballast construction, and dual tracks at grade. Dual grade-separated guideways include aerial structures consisting of foundations, footings, columns, superstructure, drains and trackwork. Unit costs are based on PATCO estimates, indexed to 1982. Dual at-grade guideways are estimated at $330.00 per linear foot. Elevated or grade-separated guideways which are to be used exclusively at road crossings are estimated at $950,000 each based on $1,000 @ linear foot for a span of 950 feet which maintains a maximum slope of 2 percent to a height of 16 feet. Dual guideways which are tunneled are estimated at $1,500.00 per linear foot.

Total reconstruction of existing facilities is necessary for all alignments in both the Modernized and Expanded Systems. Although it may be determined during inventory that existing ballast is satisfactory, it would not be prudent to make that assumption at this juncture.

9.2.6 Traction Power

This item includes all costs involved in supplying power to the vehicles. It includes the power supply system, consisting of overhead alternating current catenary wire above the tracks, power distribution, substations, poles and towers. Preliminary assessment of existing catenary indicates that the majority of overhead support facilities could be used on the Modernized System if reconditioned, as is currently being done on some of the alignments. The cost estimate of $750,000 per mile for catenary reconstruction, using existing support facilities, has been determined based on 1982 bid costs received by SEPTA. Entirely new catenary with new support facilities has been estimated at $1,100,000 per mile based on manufacturer information. Entirely new catenary will be required on most of the Expanded System alignments not also part of the Modernized System.

9.2.7 Stations

To arrive at station costs, the stations themselves must be put into categories owing to the wide diversity of stations involved. Two station types are proposed, requiring separate station estimates. The first type involves a totally new surface station equipped with full facilities and a high-level platform. This station type will dominate the Expanded System and be interspersed as necessary in the Modernized System. The second station type consists of existing stations which will require platforms and refurbishing existing shelters or else providing low cost shelters.

The unit cost for the totally new station and platform is $1,700,000, based on 1982 indexed figures for the station type designed for PATCO. The unit cost for raising existing platforms is $66,000, based on Means construction cost data. Low cost station shelters are estimated at $75,000, including utilities. The minimum length of all raised platforms is 665 linear feet in order to accommodate eight-car trains. A cost of $400 per parking space is estimated for all proposed park and ride stations requiring new at-grade lots. A cost of $18.00 per linear foot is estimated for new safety fencing on both sides of the right-of-way, for the entire length of both systems. Both preceding figures are based on 1982 Means construction cost data.

Landscaping costs are estimated at $40.00 per linear foot, based on 1982 indexed PATCO extension estimates. Landscaping is proposed at stations.

9.2.8 Signal System

The signal system consists primarily of interlockings, train stops, signal blocks, signal light preemptive devices and automatic train protection. The signal system as proposed is estimated at $315.00 per linear foot, based on manufacturers' information.

9.2.9 Communication and Surveillance Systems

The communication and surveillance system includes closed circuit television, telephone, public address system, mobile radio and train phone. A price tag of $600,000 per station is estimated, based on PATCO extension data indexed to 1983.

9.2.10 Automatic Train Control

Automatic train control is a system of automatically driving the train, encompassing acceleration, deceleration, station stopping and spacing between trains. An estimate of $800,000 per mile is based on manufacturers' information.

9.2.11 Automatic Vehicle Monitoring

Automatic vehicle monitoring includes a central control station estimated at $15,000,000, subinstallations at the rate of one per line with a cost of $60,000, and vehicle signals with a cost of $10,000 per vehicle pair. These estimates are based on manufacturer information.

9.2.12 Track Crossing Pads

Track crossing pads will be installed at all grade crossings on commuter rail lines; grade crossings will be eliminated entirely along regional rail alignments. An estimate of $30,000 per location is based on manufacturer information.

9.2.13 Maintenance and Storage Depots

Capital expenditures for maintenance and storage include buildings, large equipment for maintaining the vehicles, and machinery to keep the system operating. Yearly operating expenses, which include the necessary tools and parts used in actual maintenance, are covered in the section on operating expenses. One new major maintenance and storage facility has been determined to be necessary for the Modernized System, based on vehicle estimates. Two refurbished maintenance and storage facilities have been determined to be necessary for the Expanded System, based on vehicle estimates. Refurbishing existing depots to make them compatible with the proposed system is estimated at $500,000 per depot. New depots are estimated at $1,500,000 based on contractor information.

9.3 System Operating Costs Defined

9.3.1 General

Operating costs on the proposed transit system consist of items of expense covering day-to-day operations, including labor, material, supplies to operate the train, supplies to maintain and service the equipment, maintenance of the fixed plant, the cost of electric power produced or purchased, general and administrative expense, injuries and damages, employee benefits, and taxes.

The most common breakdown of rail transit operating costs is into the following five major categories:

1. Transportation Costs
2. Vehicle Maintenance Costs
3. Permanent Way Maintenance Costs
4. Power Costs
5. General and Administrative Costs

9.3.2 Transportation Costs

These costs include the wages of all operating personnel such as drivers, supervisors, station attendants and schedulers.

Since both proposed rail transit systems will be automatically controlled from a central point, console operators will be required for train control, station surveillance, and power control. Also, station operations will be automated to the fullest possible extent. There will be ticket vending machines, automatic turnstiles, and bill changers at every station. Maintenance engineers will be needed to correct vending machine failures, maintain escalators and air conditioning, perform structural repairs, replace lights, and service the plant.

Other station staff will include the security force. Each station will have closed-circuit television surveillance. Road patrols will visit stations on a random basis and be in radio communication with the control center at all times. An additional function of the security staff is to empty the cash from the vending machines. Finally, another category of station staff required will be cleaners.

9.3.3 Vehicle Maintenance Costs

This category includes expenditures for personnel and material needed to maintain, repair, test, and clean the cars.

Mechanical, electrical and electronic engineers will be needed. In the maintenance shops they will be helped by general laborers and clerical staff. Yard operations personnel will include hostlers (for moving cars in the yard) and car cleaners.

9.3.4 Permanent Way Maintenance Costs

This type of operating cost includes the costs of personnel and material required to maintain the permanent way, including tracks, power supply, signals and so on.

Two categories of personnel will maintain the right-of-way: the track and power crew, and the ways crew. The track and power crew will maintain the running surface, the power system, the communications system, and the trackside units of the control system. The ways crew will maintain and repair the track structure.

9.3.5 Power Costs

These are the costs of the system's energy consumption. They will be primarily the cost of the electricity itself, since all the lines will be electrified.

9.3.6 General and Administrative Costs

This category includes all the indirect costs, such as management, legal services, accounting, insurance and safety expenses, employee health and welfare benefits, payroll and property taxes, depreciation, maintenance of buildings and grounds, stationary and printing, general office supplies and expenses, and miscellaneous costs.

9.4 Capital and Operating Costs: Modernized System

9.4.1. Capital Cost Projections

Figure 9-1 itemizes all projected capital expenses as previously described for the Modernized System. The total amount of all Modernized System improvements including contingencies, planning, engineering, legal and inspection costs,

Figure 9-1

Capital Cost Estimates

Materials and Installation--Modernized System

em o.	Item	Quantities	Unit Cost	Total Cost
1.	New Route Construction (Double Track)	13.7 miles	75,000	1,027,500
2.	R.O.W., Land Acquisition a. Vacant	280 acres	50,000	14,000,000
	b. Improved	140 acres	150,000	21,000,000
3.	Guideways a. At-Grade	951,400 LF	330	313,962,000
	b. Tunnel	1,160 LF	1,500	1,740,000
	c. Elevated	110 Intersections	950,000	104,500,000
4.	Catenary a. Reconditioned	164.6 miles	750,000	123,450,000
	b. New	15.6 miles	1,100,000	17,160,000
5.	Stations a. New Surface Station	2 units	1,700,000	3,400,000
	b. Raise Existing Platform	82 units	66,000	5,412,000
	c. Low Cost Shelter	164 units	75,000	12,300,000
	d. Parking Lot	28,400 spaces	400	11,360,000
6.	Signal System	952,560 LF	315	300,056,400
7.	Communication and Surveillance	92 stations	600,000	55,200,000
8.	Automatic-Train-Operation	4.1 miles	800,000	3,280,000
9.	Automatic a. Central Control Station	1 unit	15,000,000	15,000,000
	Vehicle b. Subinstallations	19 units	60,000	1,140,000
	Monitoring c. Vehicle Pair Signals	391 units	10,000	3,910,000
0.	Track Crossing Pad	50 units	30,000	1,500,000
1.	Maint. & Storage a. New Depots	N.A.	N.A.	N.A.
	b. Reburbish Depots	2 depots	500,000	1,000,000
2.	Automatic Revenue Collection	84 stations	500,000	42,000,000
3.	Vehicles a. New	700 vehicles	850,000	595,000,000
	b. Reconstruct S.L. IV	230 vehicles	200,000	46,000,000
4.	Miscellaneous a. Landscaping	65,600 LF	40	2,624,000
	b. Safety Fencing	1,905,000 LF	18	34,290,000
	Subtotal			1,720,311,900
	10% Contingencies			172,031,190
	15% Planning, Engineering, Legal and Inspections			283,851,463
	TOTAL			2,176,194,553

and indexed to 1982 is $2,176,194,553. Rounded up, this projected cost approximates $2,200,000,000.

9.4.2 Operating Cost Projections: Modernized System

In the first stage, the system will operate with the scheduling characteristics of a commuter rail service (see Chapter 6), but will enjoy automatic fare collection and high level platforms at all stations. Taking these characteristics into consideration, the new commuter rail system will produce much lower labor costs and therefore lower costs per car-mile. The cost per car-mile for this system has been estimated to be $5.00 (see section 9.1.4 and the bibliography for this chapter).

The breakdown of the commuter rail system's total operating costs into the five categories described in section 9.3 has been estimated as follows:

Transportation Costs	23 percent
Vehicle Maintenance Costs	29 percent
Permanent-way Maintenance	16 percent
Power Costs	17 cpercent
General and Administrative Costs	15 percent

From the car-miles (see Appendix IX-1) the following operating costs have been estimated for the commuter rail system (first stage of Alternative I):

	Thousands of 1982 $	Average Daily Cost (1982$)
Transportation Costs	35,241.75	96,552.73
Vehicle Maintenance Costs	44,435.25	121,740.41
Permanent-way Maintenance Costs	24,516.00	67,167.12
Power Costs	26,048.25	71,365.07
General and Administrative Costs	22,983.75	62,969.18
Total Operating Costs	153,225.00	419,794.52

The total operating costs for each specific line of the commuter rail system will be:

	Thousands of 1982 $	Average Daily Cost (1982 $)
Marcus Hook-Lansdale	20,575.00	56,369.86
Marcus Hook-Doylestown	25,470.00	69,780.82
Paoli-Trenton	48,150.00	131,917.81
Chestnut Hill West-Norristown (King of Prussia)	24,150.00	66,164.38
Elwyn (stub)	10,080.00	27,616.44
Elwyn-Warminster	16,020.00	43,890.41
Fox Chase-Airport	8,780.00	24,054.79
Total	153,225.00	419,794.52

A more detailed estimate of the operating expenses for the Modernized System's first stage is presented in Figure 9-2.

Figure 9-2

Annual Operating Costs--Modernized System (First Phase)
(Thousands of 1982 Dollars)

Line	Trans- portation Costs	Vehicle Mainten- ance Costs	Permanent- way Main- tenance Costs	Power Costs	General & Adminis- trative Costs	Total Operating Costs by Line
Marcus Hook- Lansdale	4,732.25	5,966.75	3,292.00	3,497.75	3,086.25	20,575.00
Marcus Hook- Doylestown	5,858.10	7,386.30	4,075.20	4,329.90	3,820.50	25,470.00
Paoli-Trenton	11,074.50	13,963.50	7,704.00	8,185.50	7,222.50	48,150.00
Chestnut Hill West- Norristown	5,554.50	7,003.50	3,864.00	4,105.50	3,622.50	24,150.00
Elwyn (stub)	2,318.40	2,923.20	1,612.80	1,713.60	1,512.00	10,080.00
Elwyn- Warminster	3,684.60	4,645.80	2,563.20	2,723.40	2,403.00	16,020.00
Fox Chase- Airport	2,019.40	2,546.20	1,404.80	1,492.60	1,317.00	8,780.00
Total Operating Costs by Category	35,291.75	44,435.25	24,516.00	26,048.25	22,983.75	153.225.00

Once the proposed regional rail system is implemented, the cost per car-mile will be reduced still further. This is due first, to the use of new equipment, and second, to more efficient use of the rail system through one-person operation and automatic train operation (ATO). In this case, the cost per car-mile has been estimated to be $3.50 (see the bibliography in Section 9.1.4).

The breakdown of the operating costs for the modernized system has been estimated to be:

Transportation Costs	25 percent
Vehicle Maintenance Costs	22 percent
Permanent-way Maintenance Costs	18 percent
Power Costs	18 percent
General and Administrative Costs	16 percent

Based upon the specific operating statistics presented in Chapter 6 and the car-miles in Appendix IX-2, the cost estimates of operating the modernized regional rail system are:

	Thousands of 1982 $	Average Daily Costs (1982 $)
Transportation Costs	50,329.13	137,888.03
Vehicle Maintenance Costs	44,289.63	121,341.45
Permanent-way Maintenance Costs	36,236.97	99,279.37
Power Costs	38,250.14	104,794.90
General and Administrative Costs	32,210.64	88,248.33
Total Operating Costs	201,316.50	551,552.05

And the breakdown by each particular line of the system is:

	Thousands of 1982 $	Average Daily Costs (1982 $)
Marcus Hook-Lansdale	27,307.00	74,813.70
Marcus Hook-Doylestown	33,803,00	92,610.96
Paoli-Trenton	57,624.00	157,873.97
King of Prussia-Fort Washington	10,972.50	30,061.64
Chestnut Hill West-Norristown (KOP)	29,463.00	80,720.55
Elwyn (stub)	11,168.50	30,598.63
Elwyn-Warminster	20,370.00	55,808.22
Airport-Fox Chase	10,608.50	29,064.38
Total	201,316.50	551,552.05

Figure 9-3 provides a more detailed cost breakdown for the regional rail phase of the Modernized System.

9.5 Capital and Operating Costs: Expanded System

9.5.1 Capital Cost Projections

Figure 9-4 itemizes all projected capital expenses as previously described for the Expanded System. The total amount of all Expanded System improvements including contingencies, planning, engineering, legal and inspection costs, is $1,124,322,170.00, indexed to 1982. Rounded up, this projected cost approximates $1,150,000,000.00

Figure 9-3

Annual Operating Costs--Modernized System (Second Phase)

(Thousands of 1982 Dollars)

Line	Transportation Costs	Vehicle Maintenance Costs	Permanent-way Maintenance Costs	Power Costs	General & Administrative Costs	Total Operating Costs by Line
Marcus Hook-Lansdale	6,826.75	6,007.54	4,915.26	5,188.33	4,369.12	27,307.00
Marcus Hook-Doylestown	8,450.75	7,436.66	6,084.54	6,422.57	5,408.48	33,803.00
Paoli-Trenton	14,406.00	12,677.28	10,372.32	10,948.56	9,219.89	57,624.00
Chestnut Hill West-Norristown (KOP)	7,365.75	6,481.86	5,303.34	5,597.97	4,717.08	29,463.00
Elwyn (stub)	2,792.13	2,457.07	2,010.33	2,122.02	1,786.96	11,168.50
Elwyn-Warminster	5,092.50	4,481.40	3,666.60	3,870.30	3,259.20	20,370.00
King of Prussia-Fort Washington	2,743.13	2,413.95	1,975.05	2,084.78	1,755.60	10,972.50
Fox Chase-Airport	2,652.13	2,333.87	1,909.53	2,015.62	1,697.36	10,608.50
Total Operating Costs by Category	50,329.13	44,289.63	36,236.97	38,250.14	32,210.64	201,316.50

Figure 9-4

Capital Cost Estimates
Materials and Installation--Expanded System

Item No.	Item	Quantities	Unit Cost	Total Cost
1.	New Route Construction (Dble. Trk. Equiv.)	9.8 miles	75,000	735,000
2.	R.O.W. Acquisition a. Vacant	2140 acres	50,000	107,000,000
	b. Improved	140 acres	150,000	21,000,000
3.	Guideways a. At-Grade	329,470 LF	330	108,725,000
	b. Tunnel	1160 LF	1,500	1,740,000
	c. Elevated	40 intersections	950,000	38,000,000
4.	Catenary a. Preconditioned	24.2 miles	750,000	18,150,000
	b. New	38.4 miles	1,100,000	42,240,000
5.	Stations a. New Surface Station	15 units	1,700,000	25,500,000
	b. Raise Existing Plat.	15 units	66,000	990,000
	c. Low Cost Shelter	30 units	75,000	2,250,000
	d. Parking Lot	52,600 spaces	400	21,040,000
6.	Signal System	331,630 LF	315	104,463,450
7.	Communication and Surveillance	30 stations	600,000	18,000,000
8.	Automatic-Train-Operation	16.5 miles	800,000	13,200,000
9.	Automatic-a. Central Control Sta.	NA	NA	NA
	Vehicle b. Subinstallations	7 units	60,000	420,00
	Monitoring c. Vehicle Pair Signals	154 units	10,000	1,540,00
10.	Track Crossing Pad	NA	NA	NA
11.	Maint. & Storage a. New Depots	1	1,500,000	1,500,00
	b. Refurbish Depots	NA	NA	NA
12.	Automatic Revenue Collection	30 stations	500,000	15,000,00
13.	Vehicles a. New	418 vehicles	800,000	334,400,00
	b. Reconstruct S.L IV	NA	NA	NA
14.	Miscellaneous a. Landscaping	24,000 LF	40	960,00
	b. Safety Fencing	663,260 LF	18	11,938,68
	Subtotal			888,792,23
	10% Contingencies			88,897,22
	15% Planning, Engineering, Legal and Inspections			146,650,71
	Total			1,124,322,17

9.5.2 Operating Cost Projections

In Chapter 6 the operating characteristics and requirements for Alternative II were presented. The breakdown of the operating costs for the Expanded System has been estimated to be similar to that of the final regional rail stage of the Modernized System (see section 9.4.2), as well as the cost-per-car-mile (estimated to be $3.50). (For car-miles, see Appendix IX-3.) From these assumptions, the following operating costs have been obtained for the Expanded System:

	Thousands of 1982 $	Average Daily Costs (1982 $)
Transportation Costs	70,777.88	193,912.00
Vehicle Maintenance Costs	62,284.53	170,642.55
Permanent-way Maintenance Costs	50,960.07	139,616.63
Power Costs	53,791.19	147,373.12
General and Administrative Costs	45,297.84	124,103.67
Total Operating Costs	283,111.50	775,647.95

And the breakdown by each specific line of the system is:

	Thousands of 1982 $	Average Daily Cost (1982 $)
Marcus Hook-Lansdale	27,961.50	76,606.85
Marcus Hook-Doylestown	34,615.00	94,835.62
Lenni-Media (stub)	19,239.50	52,710.96
Lenni-Media-Warminster	26,593.00	72,857.53
Frazer-Paoli-Trenton	59,031.00	161,728.77
Norristown (KOP)-Chestnut Hill West	29,288.00	80,241.10
Trenton-King of Prussia	39,214.00	107,435.62
Trenton-Chester City	26,035.50	71,330.14
Greater Northeast	10,524.50	28,834.25
Fox Chase-Airport	10,608.50	29,064.38
Total	283,111.50	775,647.95

More detailed estimates of the operating costs by line and category for Alternative II are shown in Figure 9-5.

Figure 9-5

Annual Operating Costs--Expanded System (Alternative II)
(Thousands of 1982 Dollars)

Line	Transportation Costs	Vehicle Maintenance Costs	Permanent-way Maintenance Costs	Power Costs	General & Administrative Costs	Total Operating Costs by Line
Marcus Hook-Lansdale	6,990.38	6,151.53	5,033.07	5,312.69	4,473.89	27,961.50
Marcus Hook-Doylestown	8,653.75	7,615.30	6,230.70	6,576.85	5,538.40	34,615.00
Lenni-Media (stub)	4,809.88	4,232.69	3,463.11	3,655.51	3,078.32	19,239.50
Lenni-Media-Warminster	6,648.25	5,850.46	4,786.74	5,052.67	4,254.88	26,593.00
Frazer-Paoli-Trenton	14,757.75	12,986.82	10,625.58	11,215.89	9,444.96	59,031.00
Chestnut Hill West-Norristown (KOP)	7,322.00	6,443.36	5,271.84	5,564.72	4,686.08	29,288.00
Trenton-King of Prussia	9,803.50	8,627.08	7,058.52	7,450.66	6,274.27	39,214.00
Trenton-Chester City	6,508.88	5,727.81	4,686.39	4,946.75	4,165.68	26,035.50
Greater Northeast	2,631.13	2,315.39	1,894.41	1,999.66	1,683.92	10,524.50
Fox Chase-Airport	2,652.13	2,333.87	1,909.53	2,015.62	1,697.36	10,608.50
Total Operating Costs by Category	70,777.88	62,284.53	50,960.07	53,791.19	45,297.84	283,111.50

BIBLIOGRAPHY--CHAPTER 9

Gray, George E., and Hoel, Lester A. Public Transportation Planning, Operations, and Management. Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1981.

Institute of Transportation Engineers. Transportation and Traffic Engineering Handbook, Second Edition. Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1982.

Morin, Stephen J. National Urban Mass Transportation Statistics: Second Annual Report, Section 15 Reporting System. Prepared for the U.S. Department of Transportation, Urban Mass Transportation Administration, Washington, D. C., July 1982.

Southeastern Pennsylvania Transportation Authority. Report on the Conrail Crisis.

Urban Mass Transportation Administration and Delaware River Port Authority. Alternatives Analysis and Draft Environmental Impact Statement for the Lindenwold-Berlin-Atco Corridor in Camden County, New Jersey, October 1982.

Vuchic, Vukan R. Urban Public Transportation: Systems and Technology. Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1981.

Information directly gathered through telephone calls from SEPTA and PATCO transportation authorities, March and April 1983.

CHAPTER 10

FINANCE STUDY

by Joseph Augustyn

10.1 Introduction

10.1.1 Purpose and Scope

This finance study is primarily designed to assist local decision makers in identifying the "state-of-financing" in 1983 as it applies to the proposed Modernized and Expanded regional rail transit systems for the Philadelphia area. Financing refers to all means of paying the capital or operating costs of mass transit.

Proven traditional mass transit financing methods will be examined as well as proven methods of financing projects other than mass transit. These other financing methods have tremendous potential to augment the traditional financing techniques, when applied to the proposed systems. The integration of all feasible means of paying for the transit systems is extremely critical to the viability of the project.

The Philadelphia region can meet the financial requirements of the proposed systems through the following four general methods:

1. Borrowing
2. Sharing the financial burden with federal, state and county jurisdictions.
3. Obtaining revenue from new sources
4. Collecting revenue from passenger fares

A mere explanation of how Philadelphia can finance the proposed transit systems is insufficient. It is crucial to understand why. Public attitudes on willingness to support transit must be addressed, as should the political influence which can act as the catalyst for action.

10.1.2 1983 Financial Realities

The present method of paying for transit in Philadelphia is a losing proposition. Even if no modernization or expansion of the present transit system occurs, the system is doomed if deficit trends continue and traditional financing revenue is reduced. A linear regression projection of Philadelphia commuter rail deficits from 1977 to 1981 shows where the system could be headed:

Fiscal Year	Deficit*
1977	$43,903,000
1978	41,104,000
1979	49,022,000
1980	63,002,000
1981	59,440,000

*Deficit = Operating Revenue-Operating Cost

$$l_f = mx + b$$

$$b = \overline{y} - m\overline{x}$$

$$m = \frac{nE\ (x_1 y_1) - (Ex_1)(Ey_1)}{n\ x_1^2 - (\ x_i)^2}$$

Fiscal Year	Projected Deficit
1990	$ 109,563,000
2000	162,535,000

If these deficits continue as projected, it might be possible to continue year-to-year deficit financing by incremental increases in subsidies. Several facts, however, suggest that traditional methods will be severely altered:

- SEPTA's capital projects have been generally funded by the 80 percent federal, 20 percent local formula. The Surface Transportation Assistance Act of 1982, however, generally provides for a 75 percent federal, 25 percent local formula.
- Traditionally the 20 percent local match is funded by the Commonwealth of Pennsylvania at 16-2/3 percent and local governments and/or SEPTA at 3-1/3 percent. The state has now proposed funding only 10 percent of the 25 percent, which could leave local governments and/or SEPTA responsible for the remaining 15 percent. This represents a nearly five-fold increase of regional responsibility!

- Section 5 federal formula grant assistance provided up to 50 percent of deficit operating expenses. This program is especially critical for SEPTA's bus operation. Section 5 operating grants, however, are phased out in the 1982 Act.
- Federal subsidies to SEPTA for operating deficits amounted to approximately 33 percent of total deficits from 1977 to 1981. State subsidies covered 45 percent of the deficits and local funds covered the remaining 22 percent. A cutoff of federal funds will result in a tremendous local financial burden.
- The 1983 Act reflects a shift in federal priorities away from transit operating assistance and major new transportation investments and towards existing highway and transit systems. The Act reflects the President's effort to reduce federal intrusion in areas of essentially state and local interest.

The above facts demand that Philadelphia's transit system be financed through alternative methods.

10.2 The Economics and Politics of Transit Support

10.2.1 Why Finance: Financial and Non-financial Rationale

Public transit service confers external benefits on the entire Philadelphia region, and modernization and expansion of the present system will only increase the benefits. It is of utmost importance that this outlook become an integral part of the region's public opinion to muster political support for the Philadelphia region's public transit.

- Delaware Valley merchants, employers, and real estate interests will benefit from improved access via transit.
- Additional public transit will reduce overall energy requirements, reduce traffic accidents and congestion, reduce air pollution, and improve the overall economic efficiency and aesthetic quality of the Philadelphia region.
- Public transit provides low-fare transportation for low-income people. Low cost access to employment centers encourages job creation. Transit thus acts as a means to income redistribution and to an increase in regional employment.
- A well-financed, reliable, fast, clean, safe and efficient transit system will increase Philadelphia's national and even international recognition. This prestige will be reflected in public commitment to the Philadelphia area. Tourist dollars will increase. As a basic industry, tourism provides income from outside the region, thus increasing the overall regional standard of living. Tourism is just such a major industry in Washington, D. C., and there is no

reason why Philadelphia, with its rich cultural and historical treasures, cannot expect the same.

- The most important benefits are reductions in user and non-user travel times.
- Transit influences land use by encouraging efficient land use densities near to service lines.

Emphasizing the value of a transit system to over-all regional activity should gain financial support beyond fares paid by users. The automobile already receives this broad-based support.

10.2.2 The Players and Points-of-View

Proper identification of those presently involved in the Philadelphia area's transit system is vital for proper appreciation of the issues.

1. Actors--SEPTA, local and state planners
2. Sponsors--federal, state, city and county politicians
3. Receivers--the public

Any proposed capital project must have support from all three groups. A further understanding of how to deal effectively with these three groups is crucial for building support for a transportation system.

1. Operator-Supplier Point of View--SEPTA management and labor needs, wants and objectives must be considered. They put in time and effort, and expect salary and job satisfaction.

2. Users' Point of View--Users invest time, money, risk and effort while expecting travel in comfort.

3. Regional Point-of-View--The region contributes resources to a transportation plan. Land, energy, taxes, economic opportunity, and the environment are the regional inputs. The Delaware Valley Region should receive accessibility, movement of people, environmental improvement and land development in return.

4. Government's Point of View--The federal, state and local governments provide grants, subsidies, loans, staff and policy administration. They expect to achieve collective goals for society, which are expressed in a wide variety of terms.

Any finance scenario which ignores any of these three groups or four points of view could result in protracted problems in final funding. The scenarios for funding must be acceptable, reasonable and defensible for all players.

10.2.3 SEPTA Funding Needs, Practices and Constraints

1. SEPTA's most detrimental problem is unpredictable funding.

2. SEPTA does not have the power to levy taxes or assess local governments for subsidies to cover transit expenses.

3. SEPTA is authorized to apply for and accept federal, state and local funding.

4. The local governments are required by the state to provide $1 for every $2 of state funding.

5. The suburban counties rely on property tax revenues to finance their portion of the transit funding.

6. Philadelphia relies on property tax and the city wage tax to finance its portion of the transit funding.

7. Philadelphia pays approximately 85 percent of the local share of transit funding; Delaware, Chester, Montgomery and Bucks counties pay the remaining 15 percent.

10.3 Recent Funding Proposals and Legislation

10.3.1 State Level Proposals

The 1978 Larson Report recommended an earmarked amount of money from the Commonwealth General Fund to be set aside for transportation. It also recommended the following:

1. That the state fund 75 percent of the portion of the deficit not covered by federal funding.

2. That local governments be given the option of levying transit-specific taxes.

The "Baker Committee" agreed with the Larson recommendations and added the following:

1. That each year a 9 percent state personal income tax be set aside for a transit fund. The amount collected would increase with income, thus keeping pace with inflation.

10.3.2 State Funding: Existing Legislation

Act 101 of 1980 became effective on January 1, 1981. This Act provides the following:

1. That each local transit authority receive at least 67 percent and not more than 75 percent of its remaining deficit not covered by federal funding.

2. The variation between 67 percent and 75 percent depends on operating performance and the amount appropriated each year by the General Assembly.

It should be noted that actual appropriations to date have been less than 67 percent of the deficits.

10.3.3 Regional Level

The Philadelphia Chapter of the American Society of Public Administration recommended the following:

1. That a special regional tax be earmarked for mass transit.

2. After considering a regional property tax, personal income tax, retail sales tax and a gasoline sales tax, the group recommended a regional tax on gasoline sales.

It should be noted that this sort of regional tax has not gained much support. However, the City of Philadelphia has indicated support for the idea because costs would be spread more evenly throughout the region.

10.4 Financial Requirements of the Proposed System

10.4.1 Capital and Operating Costs

As determined in Chapter 9, the projected capital and operating cost requirements calculated in constant 1982 dollars for the Modernized System and for the Expanded System are summarized as follows:

	Modernized System	Expanded System
Capital Cost Total	$2,200,000,00	$1,150,000,000
Operating Cost per Year	$ 201,316,500	$ 283,111,500

The farebox revenues were also examined and estimated as follows:

	Projected Fare Revenue
Modernized System (Commuter and Regional Rail)	$138,048,140
Expanded System	$226,011,630

Operating costs minus projected revenues yield the following amounts which have to be financed:

Operating Finance Requirements

	Modernized System	Expanded System
Total Operating Cost Not Covered by Fares	$63,268,360	$57,099,870

Mass transit is no longer self-supporting. In the aggregate, however, it does cover approximately half its operating costs from fares. An example is Montreal's system, whose operating revenues amount to 50 percent of its total costs. The system is currently subsidized at the rate of $150 million per year. One of the most successful systems in North America is the Toronto Transit Commission, which meets 68 percent of its expenses from the farebox. (It should be noted that Toronto also has the highest per capita transit ridership rate.) SEPTA presently meets approximately 45 percent of its operating expenses through fares.

These figures demand support for the idea that transit is a public service rather than a private enterprise. Although professional business practices must be part of managing the system, the system should not be judged strictly by its financial statement. Capital and operating subsidies are a payment by the community for services that the transit system provides. These services were outlined in section 10.2.1, Finance Rationale.

10.4.2 Capital Finance Parameters and Contraints

The funding of capital budgets for large, complicated construction projects demands careful scheduling, since the federal, state and local grants, and the funds from bond issues must be geared to contract payment schedules. The following parameters shape the capital financing scenarios of the proposed transit system:

1. Federal (section 3) grants are generally the chief funding source for large transit capital expenditures. These funds are discretionary; and must be negotiated with UMTA and DOT. There is competition among the transit authorities in the Region III jurisdiction, which includes Delaware, Maryland, Pennsylvania, Virginia, District of Columbia and West Virginia.

2. Approximately $100 million per year is expected to continue to be made available to UMTA Region III in the short term. This includes the one cent gas tax designated for transit.

3. This $100 million per year is made available through the following programs:

    a. Section 3--Discretionary grants available for acquisition, construction, reconstruction and improvement of facilities and equipment. It also provides for establishment of public or quasi-public transit corridor development corporations.

    b. Interstate/FAUS Funding--These highway trust funds have also been made available for mass transit. A number of large urban areas, such as Boston, have deleted urban Interstate Highway segments in order to use the funds for mass transit instead.

c. Section 5--These formula grants are based on population densities and transit rate-miles. These funds provide for the acquisition, construction and improvement of facilities and equipment.

d. Section 8--These funds are for planning assistance and technical studies related to the planning, engineering, designing and evaluation of urban and regional transit projects.

e. Other Grant Programs--Other programs include managerial training, value capture, facilities for the handicapped, and urban initiative, including joint development, intermodal facilities, parking lots, and vehicle purchases.

4. Federal capital grant assistance may be provided on a long term basis with a matching proportion of 75 percent federal, 25 percent local funds. A complex, involved grant application procedure is required for this type of funding.

5. Federal funding of operating expenses will be phased out.

6. The 25 percent local matching funding will be met using proposed state funding of 10 percent (down from 16-2/3 percent of the previous 20 percent match) and 15 percent from local governments.

7. Great difficulty is expected in raising the 25 percent matching funds. This is especially evident in view of

the state's reduced willingness to finance Philadelphia's transit system.

8. The continuing burden of subsidizing the current operating budget, as projected, must not be overlooked.

9. A reasonable time estimate for completing the expanded system is three years for planning, three years for pre-engineering and engineering design and twelve years for construction.

10. Project planning, pre-engineering and engineering costs were estimated at 10 percent of total project cost. This amount is consistent with PATCO extension estimates. Legal and inspection fees were assumed at 5 percent.

11. The total project capital cost, including both the Modernized and Expanded Systems approximates $3,350,000,000. This is the target amount for financing in all scenarios. Financing the Modernized System only can be generally evaluated by using a factor of .66.

10.5 Proposed Capital Funding Scenarios

10.5.1 A Traditional Approach: Scenario #1

It has been determined that $3.35 billion will be required to finance the Expanded System. $90 million payable each year could reasonable be made available immediately, through federal funding and local matching ($50 million federal, $40 million local) based on the established parameters. This amount would be sufficient to account for present operating subsidies plus the planning and engineering costs expected during the first six years of the project. The next twelve years of construction would require payment of another $3,015 billion. Assuming 75 percent federal matching, $.753 billion would have to be raised locally. This approximates $63 million per year in addition to existing subsidy requirements. A traditional method of raising local capital is through the local property tax.

As the result of problems finding transit funding sources, many cities have had to raise existing broad-based property taxes. This is evident in the fact that thirteen cities have passed new property taxes since 1981 to help fund local transit.

The estimated amount (in 1982 constant dollars) which would have to be generated regionally through a dedicated property tax is indicated below. The regional amount includes the required capital funding of 15 percent of project costs. State matching funding of 10 percent is consistent with proposed legislation. 75 percent federal matching is assumed.

Total Project Cost	$3.35 Billion
75 Percent Federal	2.51 Billion
15 Percent Regional	.50 Billion
10 Percent State	.34 Billion

A fifteen year, federally-secured 10 percent municipal bond issue by the city would yield the entire 15 percent regional amount required. A fifteen-year amortorization schedule for $500 million at 10 percent would require an annual payment of $50 million for the interest. Upon expiration, the bond would be refinanced as a serial bond for another fifteen years and then retired.

Coupled with the present regional share of the operating deficit, the new amount required from the region to finance both the existing deficit and the construction of the Expanded System is approximately $68 million annually. This represents a regional transit payment increase of 566 percent. The state's share would be $70 million annually, or an increase of approximately 270 percent.

10.5.2 A New Suggestion: Scenario #2

The following critical analysis was offered by Dr. Anthony R. Tomazinis in an unpublished paper dated July 1982:

> Clearly it is appropriate to start thinking about a much more basic solution to the commuter rail problem of this region.

The present system has four major shortcomings which must be addressed by an improvement plan: high operating costs, obsolete technology, obsolete layout, and minimal ridership.

Dr. Tomazinis offered the following scenario. The Improvement Plan for 2000 would consist of two parts:

1. Regional governments should establish as an objective the creation of a modern regional railroad system.

2. A formal agreement among the local governments and state should set forth the following:

  a. SEPTA will discontinue commuter railroad service and will institute a complete intermediate-range plan in its place, as outlined in the Orth-Rogers Study involving express bus service.

  b. The state and local governments will continue to contribute support to the amount of $50 million annually, which approximates present local deficit funding.

After providing for the estimated $2.25 million deficit for the commuter express bus lines proposed in the Orth-Rogers Study, the remaining $47.75 million be used for the planning, designing and construction of a modern regional rapid transit system (RRTS). An investment/borrowing program should maximize interest and returns. Applications should also be submitted for federal capital funding.

A concluding construction date suggested as seventeen years hence will produce capital of $850 million, producing a revenue level of about $100 million annually (12 percent return estimated). This level of revenue would be enough to cover any deficit operations, plus planning, design and the local share of federal construction support.

Considering a ground-level system with separate rights-of-way, an average cost of $30 million per mile would amount to $6 billion in 1982 dollars for a 200-mile system. The financial mechaniam described could finance such a system.

A thorough review of this proposal should be made in view of supporting data supplied by Dr. Tomazinis.

10.5.3 Dedicated Revenue Sources: Scenarios #3a, b, c and d

It has been shown that a major problem impeding improvement of the existing system is the lack of predictable funding. A dedicated revenue source would solve this problem.

Enacting dedicated sources of financing for Philadelphia area's transit system is a complex task which could involve two levels of activities:

1. It may be necessary first to secure authorization from the Pennsylvania State Legislature.

2. Secondly, approval by the local representatives would be necessary.

An active campaign for such a program has not been attempted for Philadelphia. Nationwide experience to enact this procedure suggests that gaining approval at either level is unlikely to succeed on the first try. This being understood, the area should now establish the type of dedicated revenue source which would be most appropriate for the Philadelphia Region.

Scenario 3a: Sales Tax. Most cities prefer an additional local sales tax. However, in Philadelphia's case, new authorizing legislation at the state level would be necessary. This could be very difficult to enact. In addition, the sales tax is very inequitable in terms of percentage of personal income for different socio-economic groups. This inequity is inconsistent with the stated goals of this study, and is therefore not pursued. This does not, however, preclude the feasibility of funding transit through a sales tax.

Scenario 3b: Motor Vehicle Use Tax. Transit benefits motor vehicle users by reducing traffic congestion, and thus reducing travel time for the motor vehicle user. This is supported by the increased traffic congestion in Philadelphia during SEPTA strikes. Motor fuel tax, motor vehicle tax, parking charges and tolls are four main types of motor vehicle use taxes.

Although the motor vehicle use tax was not pursued for capital funding in this study, it does not preclude the feasibility of this method of financing. Regional disadvantages of this type of tax were found to be in conflict with study goals.

The motor fuel tax is regressive in that it falls more than proportionally on low income groups. A personal property tax on automobiles is less inequitable, but it is generally a state tax, thus, increasing political opposition.

Flat-rate license fees are least equitable. Additional parking charges have been met by local business opposition. The use of highway tolls and increases in existing bridge tolls for transit are also heavily opposed in Philadelphia. The PATCO Lindenwold line is already partially financed from DRPA bridge tolls. Based on these major considerations, a Motor Vehicle Use Tax is not recommended for the Philadelphia region.

Scenario 3c: Value Capture through Property Taxation. Property taxation is the major source of local revenue in the Philadelphia region. Since it is already authorized, it needs only local approval for an increase. Across the board property tax increases for the region are not equitable in terms of transit benefit, however. A newer type of property tax, such as special assessment, is more directly related to those who receive monetary benefits from transit improvements.

A financing scenario for special benefit assessment warrants consideration because the capital improvements proposed in this study will confer benefits to most of these property owners at and near the transit stations. Either higher land values or improved market performance is expected. The following assumptions were made for the special benefits assessment scenario:

1. Density is the single most important determinant of urban land value.

2. A transportation nucleus such as a transit station tends to concentrate development in the general area of the station.

3. An increased demand for space results in increased rents and higher land values.

4. Public benefits do not necessarily produce uniform effects on adjacent parcels, since many factors affect property use and value. Some parcels appreciate more than others.

5. The perpetuity capitalization formula: $v = \frac{R}{t + r}$, applies to our proposed special benefit assessment where

v = parcel value
R = anticipated annual rental before taxes
r = annual required rate of return
t = real estate tax

6. The proposed special assessment has the potential to seriously impair investment if improperly imposed. The assessments should be applied as liens only on benefited properties as the benefits occur!

7. All figures generated at this concept stage are based on reasonable assumptions rather than on any systematic detailed model.

8. The proposed Joint Development Plan outlined in Chapter 5 would work hand-in-hand with special benefit assessment.

The following schedule is proposed for applying the proposed special assessment. This assessment will be in the form of a True Value Increment Tax (VIT) where only those who benefit would be taxed.

1. For a given parcel, the tax will be the increase in assessed value over the base year multiplied by the incremental tax rate.

$$t_i = V_o \ (b)$$

$$T_i = V_o^1 \ (b) + V_o^1 \ (s) - V_o \ (b)$$

Where: t_i represents present tax revenue in a given year i, obtained by multiplying V value of property o by tax rate b. T_i represents the new tax revenue, V^1 is the incremental value of property o and s is the incremental tax rate.

2. The increment of value of the benefitted property would be based on actual value increase minus the value increase which would have occurred anyway. A community average of value increase could be utilized.

3. The VIT will apply to incremental increases in value of land, plus all improvements.

4. Base period values will be set for parcels in the designated areas, and increases in value in a taxable year will be determined by subtracting expenditures for new improvements.

5. A review of the Modernized and Expanded System stations yielded sixteen stations which appear to have potential for value increase and thus value capture. One hypothetical "average" station area will be analyzed for potential return, and this figure will be projected for the other stations.

6. The hypothetical station benefit area is estimated at a radius of 2,000 feet from the station. This radius directly coincides with the proposed development district outlined in the joint development proposal in Chapter 5. This yields a building area of approximately 6 million square feet, assuming 50 percent building coverage. Based on assessor estimates of present taxable property values for medium density low-rise development near several stations within the reject area, an assessable value of $15 per square foot is the assumed average. This yields a base value of $90 million. An incremental increase of 50 percent is estimated, due to relatively low present value based on only medium density. This 50 percent increase is consistent with other similar joint development projects.

The property tax for Philadelphia in 1983 is approximately $2.50 per $100 assessed value. A tax of $2.50 per $100 is assumed for the hypothetical case. A VIT of 8 percent is imposed on value increment.

Hypothetical Station Value Increment Tax

Base Value	$90 million	($15 @ S.F. x 6 million S.F.)
Base Tax Revenue	$2.25 million	(2.5 percent per annum rate)
Post Benefit Value	$135 million	(50 percent increment)
Increment Value	$45 million	($135 million-$90 million)
VIT + Base Tax on Increment Value Exclusive of Base		
Tax Revenue	$4.725 million	((8 percent + 2.5 percent) x $45 million)

A total annual tax increment, excluding base revenue, will approximate $75 million, based on sixteen benefit-assessed station areas.

6. The best use of these tax increment funds is arranged through bond financing. Since the revenues accumulate only gradually over time, the tax increment device can be used to provide immediate funds only if issued against prospective revenues with government backing.

A thirty-year bond is proposed for issuance. Full incremental tax revenues are not to be expected until construction is completed, therefore the debt service deficit must be financed in other ways. A twelve-year construction period is assumed with rising VIT Revenue beginning in the fourth year.

The alternative method proposed will consist of tax-free municipal bonds, issued with a graduated interest rate. A lower debt service will be required initially. The debt service will increase incrementally to a higher amount, with an average interest yield slightly higher than standard bonds. A standard fifteen year tax-free bond was assumed at 10 percent interest, the Graduated Interest Bond for thirty years will be assumed at 13 percent interest.

Since long term commitment to these bonds will be required in order to realize the higher yield, they will be issued to an institutional sponsor who will sell unit trusts. The sponsor will absorb the reduced initial rate through guaranteed revenue borrowing at a rate slightly lower than the long term yield of the Graduated Interest Bond.

The full $75 million VIT is not expected until construction is completed. Reduced amounts of VIT could be realized approximately four years after construction was commenced. Increments to this revenue would be approximately $8.3 million per year for the fourth through twelfth years of construction, to a peak of $75 million. The total amount of VIT collected over a thirty-year bond life beginning from the first construction year would be $1.75 billion, with an average annual VIT of $58 million starting from the first bond year. This $58 million per year would retire a 13 percent bond of $450 million in thirty years.

This $450 million would nearly meet the 15 percent regional requirement of the full $3.35 billion capital cost estimate as previously discussed. The $50 million difference could be made up through various investment techniques as discussed below in Scenario #4.

7. Another method of raising large capital without immediate outlay for debt service is through Zero Coupon Bonds. A fifteen year Zero Coupon Bond would be issued for approximately 250 percent of the amount necessary, but then sold at a discount rate equal to an annual capital gain for the holder of 10 percent per year. No interest would be due for the entire fifteen years, but the entire note, 250 percent of actual need, would have to be paid fifteen

years hence. The note could be paid or refinanced in future deflated dollars at a time when VIT would be accumulating funds after all the improvements would be installed. For example, a zero coupon bond for $1.25 billion would be sold at a discounted rate of $500 million. The full $1.25 billion would be due in fifteen years, which would be paid in future dollars through a revenue bond using VIT revenue.

Scenario 3d: Payroll Tax. Another category of transit beneficiaries is composed of employers of transit riders. They benefit in the following ways:

1. Access to a larger labor force
2. Greater degree of reliability of employee transport
3. Reduced need to provide parking for employees

Devising a benefit-related tax for employers for transit support is very difficult since many options, variations and situations exist. The relation between charges and benefits is rough at best. Two techniques do, however, emerge. These include the employer payroll tax and the direct employer subsidies.

An analysis of these two methods in the context of the Philadelphia region and the Value Increment Tax Scenario presented, indicates inherent problems in this type of transit financing.

1. Philadelphia's present local income tax is intensely disliked and is the highest of all flat-rate wage taxes in the

nation. An additional employer payroll tax would likely meet strong political opposition.

2. The proposed VIT financing method will already accumulate a transit benefit tax from employers within one-half mile of various stations. An additional payroll tax would be a duplicate tax. The VIT is expected to have a much higher yield, and it allows for a more equitable application. The payroll tax would discourage employers from locating within the designated VIT Benefit Zone.

A payroll tax may be a viable method of financing, but since its disadvantages appear to outweigh its benefits, it is not pursued in this study.

10.5.4 Borrowing: Scenario #4

Borrowing has been proposed as a source of immediate financing for the required capital improvements. The method of borrowing was indicated as bond financing through municipal obligations. Serial Bonds are utilized generally since they allow full pay-off in installments and they are also popular. Bond financing is proposed as an integral part of the traditional financing approach (Scenario 1) and the value increment tax approach (Scenario 3c). A Revenue Bond, issued by a public agency with funds earmarked for transit improvement, could be used as shown in Scenario 1 above. A Special Assessment Bond, to be repaid from special assement revenues, would be floated in the VIT scenario.

The act of borrowing through municipal obligations can generate revenues itself if properly timed and executed.

The essence of this scenario lies in the fact that if a bond sale precedes the need for funds, excess cash can be temporarily invested in federal obligations--and at a profit! The profit comes from investments in taxable federal obligations which yield more than tax-exempt municipal obligations. In order to placate the U.S. Treasury, this device would only be used for temporary investments of funds which would eventually be used for the transit system. The assumptions in this scenario are as follows:

1. Thirty-year tax-free municipal obligations are issued with an interest rate of 10 percent.

2. Temporary re-investment of the bond funds will be made in taxable government securities at 13 percent interest. A 3 percent difference between taxable and non-taxable securities is reasonable.

3. The amount obtained through the bond will total the projected cost in constant dollars plus an amount equal to the expected inflation rate (10 percent) to the due date for construction payment.

The schedule for implementing Scenario 4 is as follows:

1. The project capital cost is estimated at $3.35 billion in 1982 constant dollars. Since construction is expected to take place six years hence, with construction lasting

twelve years, the added inflation rate will affect the amount required.

2. A $3.35 billion bond, sufficient to pay capital costs in 1982 dollars, would have to be increased to $5.3 billion to account for an estimated 10 percent annual inflation.

3. The yearly debt service for a $5.3 billion bond would be approximately $530 million.

4. A $5.3 billion bond invested fully at 13 percent for six years would yield $955 million above debt service.

5. The 13 percent investment would be slowly liquidated over a twelve-year span to pay construction costs. This added interest would account for another $960 million in earnings.

6. The interest earned would pay debt service for nearly four years of the thirty-year bond.

7. The region could at that point pick up the debt service using 75 percent federal, 25 percent local match. The regional share would be $79.5 million.

10.5.5 Multiple Options: Scenario #5

Philadelphia's transit system presently lacks a single adequate dedicated revenue source. As a result, it will be necessary to build a politically broad-based support package which draws revenue from several unrelated sources. An overview of several of these sources is provided below. The many variables involved with these revenue sources prevent even the most general monetary estimates from being formulated.

10.5.5.1 Lottery. In Pennsylvania, lottery receipts are partially dedicated to transit to make up for the income lost by local agencies because of the reduced fares paid by senior citizens during off-peak hours. Studies have shown that approximately 38 percent of the elderly do not own cars and must rely on public transit for part if not all of their trips.

Under Philadelphia's present system, anybody sixty-five years or older may ride free during off-peak hours. Lottery receipts help subsidize this discount. Pennsylvania's lottery receipts, however, do not provide transit revenue equal to the cost of providing free service to the elderly.

An age-categorized survey of Philadelphia transit users was recently completed. This survey identifies the disproportionately high percentage of elderly actually using public transit as compared to their share of the population. The study proves that transit serves critical need of the region's elderly.

This argument could prove successful in obtaining further revenues in addition to the present lottery receipts. The state of Arizona, whose lottery produces but a fraction of that the Pennsylvania lottery produces, provides an equal amount of funds for transit. These funds could help defray debt service or operating expenses.

10.5.5.2 Property Sales. A complete inventory of all transit-owned properties in the region should be taken. Those properties which are not important to the regional rail system should be sold. Other public lands owned by county or city governments which are adjacent to transit properties and are not important to the proposed system could also be sold. Consistent with present federal policy of disposing of unused properties, Philadelphia's transit system could also raise capital to help defray debt service for the new system.

10.5.5.3 Equipment Trust Certificates. The sale of equipment trust certificates is a method of raising local matching funds for capital equipment. The certificates are secured by the equipment purchased with the certificate proceeds. The City of Philadelphia, acting as trustee, holds title to the equipment and leases to SEPTA for an amount that equals debt service. Title to the equipment reverts to SEPTA when the note is paid. This is a relatively low-risk investment and may be sold at lower interest rates than more conventional securities.

10.5.5.4 Safe Harbor Leasing. A transit authority can issue tax-exempt obligations and lend the proceeds to a tax-paying entity that will obtain and then lease the transit vehicles back to the agency. This provision, called Safe Harbor Leasing, allows the tax-paying company to receive favorable tax benefits of ownership, including depreciation deductions. In return for those tax benefits, the lessor finances a portion of the cost of the transit equipment.

MTA in New York City is taking advantage of this method of financing, and is saving millions on the purchase of new vehicles by selling the depreciation tax breaks to a private company.

10.5.5.5 Joint Development. A comprehensive joint development strategy is presented in Chapter 5.

10.6 Proposed Operational Funding

Upon completion of the system, it is estimated that users would provide approximately 70 percent to 80 percent of the operating costs through fares. In order to meet all expenses, a new cost-sharing program is proposed, based on the benefits received by each main group of beneficiaries. These groups include users, the federal, state, county and local governments, and such non-users as property owners, motorists and employers.

Users' Contribution

Users benefit directly. In this respect a new fare structure would be based on the following criteria:

- Fare would be set in relation to costs generated.
- Fares would be integrated with all transit modes in order to eliminate competition.

- An annual fare adjustment would be made according to increases in costs and passenger traffic.

Federal Government's Contribution

The federal government has in the past contributed more for operations than the benefits accruing to the nationwide population at large. Presently they intend to phase out operating subsidies. Since this project will not be in operation for nearly two decades, a more reasonable contribution program, based on overall societal benefits received, could well be arranged.

State, County and Municipal Contribution

The municipal/county/state contribution would be based on the services provided in their respective territories and on the benefits derived in terms of mobility, quality of life and positive economic impact. This program for local contribution is similar to what exists today. The study group, however, is proposing that a much broader range of variables be used to determine the benefits which the individual localities derive from the proposed transit system.

Non-Users' Contribution

The principal non-user beneficiaries are motorists and businesses. These groups would be called upon to make a financial contribution according to the benefits they receive. A program of contributions for capital improvements by businesses is outlined above under the VIT scenario. The property taxes levied on the properties near the stations would be extended beyond retirement of the bonds, for the purpose of funding operating costs. Motorists would be assessed a minor contribution through existing fuel taxes and commercial parking taxes.

10.7 Novel Financing Techniques

Operating costs may also be defrayed through a number of novel methods. Although they may not contribute major amounts to the system, those methods can be image-boosting and attention-getting. Most important, however, is their psychological impact on reinforcing the concept that the transit system itself is progressive and trying its absolute best to be self-sufficient through its own resources. Studies have shown that people and governments are much more willing to contribute when they know that the recipients are trying their best.

The following methods should be considered:

1. The Metro-North commuter lines in New York and the Rock Island in Chicago presently provide snack bars in their express commuter trains, serving coffee and light breakfasts. In addition, the Rock Island has placed video games in the cars and they have been very popular.

2. All weekly and monthly TrailPasses could have sequential numbers assigned to them. These random numbers could be used as the basis for awarding small prizes through weekly

drawings. Judging from Philadelphia's enthusiasm towards the state lottery, regular commuters would certainly enjoy playing a transit lottery.

3. Banks have already shown interest in installing automatic bank teller machines in station areas. Rental would be charged from the banks for permission to place this service in the stations.

4. A full program of selling advertising space in station areas, within railroad right-of-way between stations, and on the vehicles themselves should be instituted. A stepped-up program from what exists today is recommended. As in the Montreal Metro, it is important to integrate provision for advertisements into the overall graphic program. This further enhances the effectiveness of each individual advertisement. It is important to avoid the cluttered effect produced in London's rapid transit stations, caused by an attempt to sell every square inch of wall space to advertisers.

5. Designated street musician areas could be established at stations and legitimate acts could be encouraged. The Toronto Transit Commission has actually held auditions for would-be subway musicians, awarding permits to the most qualified aspirants. Philadelphia's image of having a colorful array of street acts is presently helpful to tourism.

10.8 Summary

Financing major public projects presents many choices. Strictly financial choices, involving borrowing techniques and such finance methods as the use of trust certificates, demand technical decisions. However, the social choices, involving the question of who pays, are the most difficult. Any serious examination of applicable financing methods must make recommendations about these very choices. The ultimate financing decisions required for this type of project _must_ be based on a precise assessment of exactly who benefits and to what degree.

CHAPTER 11

EVALUATION

by Mehdi Hitewesh (Evaluation)

And the Entire Study Team (Recommendations)

11.1 Evaluation

11.1.1 Introduction

The preceding chapters have discussed various aspects of the Modernized and Expanded System alternatives for the future of the Philadelphia area's commuter rail lines. This chapter evaluates both alternatives in terms of economic and performance characteristics. The two alternatives are tested both against each and against a "do-nothing" alternative, that is to say, the present system plus the Center City tunnel and the Airport line (which are nearing completion). Each alternative is considered as whole, taking all its advantages and disadvantages into account.

An evaluation matrix (Figure 11-1) has been devised to show the alternatives' characteristics and score them in terms of 26 evaluation factors chosen by the team. These evaluation factors come from examination of the viewpoints of the four principal actors involved in the alternatives: the system's users, the operator, the community at large, and governments (federal, state and local).

The study group did not have enough time to carry out as exhaustive an analysis as is set forth in this chapter. Nevertheless, a complete evaluation such as described in these pages is necessary in order to make an informed decision on the future of the region's rail system.

Often in planning, "evaluation" is used merely to refer to descriptions of planning proposals. Here the word is used in a more formal sense, to mean the process of analysing a number of alternatives in order to determine their comparative advantages and disadvantages within a logical framework.

An evaluation must provide detailed information about all the positive and negative impacts of the alternatives on all the relevant actors. The evaluation must be concerned with the goals and objectives, the decision-makers, and the systems' efficiency and costs (both capital and operating). The decision to select a preferable alternative is based on the outcome of the evaluation process. The proposed system's performance, safety and reliability must be thoroughly proven in engineering and systems research terms.

11.1.2 Study Methodology

In researching the feasibility and desirability of transforming the Philadelphia area's commuter rail lines into a modern regional rail system, the study team considered two approaches: Alternative I, the Modernized System, and Alternative II, the Expanded System. The team did not begin work on Alternative II until work on Alternative I was virtually complete. In order to expedite the study, the team divided the work into a number of subtasks, with work on several of these often in progress at the same time. Subtask groups discussed their findings with the entire study team.

Before starting on the study, the team agreed on several goals and objectives: to design an efficient, economical, modern, high-speed, high-capacity rail transit system for the Philadelphia region, using all applicable methods of reducing operating expenses. When working on Alternative I, the team considered such factors as technological obsolescence, operating cost, and ridership projections for the year 2000. For Alternative II, the group expanded its concerns to also encompass alignment obsolescence, the high volume of suburb-to-suburb travel, and coordinated land use/transportation planning.

This study considers two alternative futures for the area's rail lines in detail. The land use issues, alignments, technology, stations, operations, fares, ridership, capital costs, operating costs and financing methods have all been dealt with in the preceding chapters.

For evaluation purposes, a third alternative is also considered: a "do-nothing" alternative which fails to address any of the issues the study team considered in its work. This is essentially the alternative which the region has implicitly chosen to date. The system's current woes, as described in Section 4 of Chapter 1, stem from the high costs of providing the service, and the problems of who is to pay for it all (and how). The recent administrative transfer from Conrail to SEPTA does not necessarily mean that any basic changes will occur. The same system is being operated by the same personnel, who belong to the same unions and are governed by the same labor practices, using the same technology to provide the same service. The system is presently caught in a vicious spiral of increasing costs and fares, and decreasing patronage and service. Carried through to their logical conclusions, these trends point toward the end of commuter rail service in the region altogether. Therefore, in order to preserve and improve this important regional asset, it is imperative to find a way to operate the service without incurring such high operating costs.

11.1.3. Evaluation Methods

An immediate question facing transportation planners in carrying out an evaluation is how to carry out the evaluation. Can the benefits (operating revenues and others) be easily compared with the costs? Costs too difficult to quantify in dollar terms include air pollution and noise, which affect both users and non-users. Non-quantifiable benefits range from decreased traffic congestion to improved transit access to areas which can now be reached only by car. In a comprehensive evaluation, detailed information about each system alternative and its impacts should be provided and summarized for comparison purposes.

The next issue is the perspective of the evaluation. The alternatives can be assessed from the viewpoints of the federal, state or local governments, the community at large, the users, the system, operator, or all of these. In each case, the relationship between the evaluation and the various actors is very different. The federal officials will probably be most interested in the capital cost, the state government will focus on both capital and operating costs, and the region's jurisdictions will be worried about the operating costs, equity implications, land use patterns, and overall acceptability of the alternatives. The community at large will want to get its money's worth on whatever investment is made, the users will want good, reliable, moderately-priced service meeting their travel needs, and the operator will want a system that is easy and economical to run.

Another issue to be considered is what is to be assumed in terms of federal, state and local government policies, and in terms of regional population and employment trends. Finally, after dealing individually with a wide variety of matters, the evaluation has to bring all the issues and facts together.

Usually, it is straightforward enough to measure the superficial costs and benefits: the capital and operating costs, revenues, etc. There are also other hidden costs and benefits related to the system, which are often harder to translate into dollar amounts. But without cost-benefit analysis, it is hard to get started with the evaluation process.

Cost-benefit analysis has long been a key element in the decision-making process for public transportation. In the U.S., it is required for any application for federal capital assistance to new transportation projects under the 1970 U.M.T.A. legislation. Cost-benefit analysis has helped many urban areas look at their transportation priorities more carefully. As a result, many cities have built rapid transit and regional rail systems, such as Philadelphia (Lindenwold), Toronto (TTC), San Francisco (BART), and Paris (RER). Others, such as Montreal with its plans for a Regional Metro, are similarly opting for a rail-based approach to metropolitan transportation problems.

As the preceding chapters clearly show, there is a very wide range of relevant considerations to be taken into account when evaluating alternatives such as those presented in this report. The more factors that there are to be measured, the more complex and involved the evaluation process becomes. Yet these evaluations must be carried out properly and well, for interest in public transportation is growing all over the world, and transit investments are consuming more and more resources and wealth.

The dilemma, then, is that while people demand more and better public transportation, the evaluation process itself grows harder to follow as increasing amounts of facts, possibilities and concerns of the day demand attention and require comparison with one another. The major issues in evaluation tend to revolve around the nature of the decision-making process, the region's goals and values, the costs and benefits, and the alternatives' overall influence on the lives of the people they affect. It must be recognized, however, that no matter what evaluation techniques are used, it is impossible to measure everything. Therefore, wisdom, intuition and common sense will always have important roles to play in evaluation.

Any new transportation system clearly affects the well-being of users, operators, society in general, and government. Three issues concerning all parties are the distribution of service (i.e., who gets what), gains and losses between groups, and the relative importance of the various groups themselves (which puts weighted values on the different gains and losses for evaluation purposes.)

Practicing planners, consultant teams and public agencies carry out evaluations, using economic, social and environmental evaluation methods. More recently, planners, agencies and transportation authorities have become increasingly aware of the multiple evaluation. It is now realized that the economic-social-environmental evaluation alone is not up to the task of judging and selecting the best solution to the problems at hand.

The advantages and disadvantages of alternatives can only be judged against specific criteria, and a good alternative must perform relatively well when weighted against the established criteria. Possible evaluation methods include:

1. Economic evaluation. Economic evaluation is based on the concept that transportation improvements result in some benefits to system users and the community as a whole. The costs and benefits of different alternatives may be economic or non-economic, depending on whether they affect the production and consumption of wealth. Three economic methods have been applied to many transit evaluations. These methods are:

- Least Total Cost: The recommended alternative is, obviously, the one with the least total cost.
- Marginal Cost/Benefit: The recommended alternative is the one whose rate of return is equal to or greater than a rate which has been previously determined to be acceptable.
- Benefit/Cost Ratio: Broadly similar to the previous two methods, the B/C Ratio method differs in that it does not necessarily indicate that the alternative with the highest ratio is preferable.

2. Analysis Models. In its simplest form, this method analyzes the alternatives in terms of a number of criteria representing the alternatives' desired attributes. The judgment as to the preferred alternative is a subjective one, highly dependent on the criteria used. The measurement of advantages and disadvantages is central to this method. However, no strong decision can be based on this method. Nevertheless, it is easy to determine the main aspects of each alternative this way.
3. Matrix Method. This is a systematic way of showing the range of alternatives and scoring their

attributes. The main areas of consideration are spelled out and put in order of priority. The higher the score, the more desirable the alternative.

4. Goals and Objectives - Achievement Analysis. This method attempts to determine the extent to which alternative plans will achieve a predetermined set of goals or objectives. Distinguishing features of this model are the attention it gives to equity considerations and its use of a hierarchy of goals and objectives. Furthermore, objectives are not valued in and of themselves, but only insofar as they help achieve certain higher-level goals, concerned with such issues as social justice, and choice and opportunity.

11.1.4 Evaluation matrix

Several evaluation methods were discussed and considered in the course of the study group's preliminary evaluation process, but the team chose the evaluation matrix as the most visually direct way to showing how the alternatives compared in a variety of terms. Figure 11-1 summarizes the team's conclusions.

The twenty-six evaluation factors are all areas of concern to at least one of the four main actors: users, operator, the community, and government. After listing the

Figure 11.1

Evaluation Matrix

EVALUATION FACTORS	Service Availability	Subsidy Required	Passenger Convenience	Return on Investment	Operating Cost	Efficiency	Transportation-Land Use Coordin.	Social Impact & Equity	Reliability of Service	Safety & Security	Capital Cost	Ridership	Regional Attractiveness	Cost of Travel	Joint Development	Regional Integration	Revenues	Economic Impact	Transportation Network Coordin.	Passenger Comfort	Environmental Impact	Local Politics	Traffic Impacts	State Politics	Construction Impacts	Federal Politics	TOTAL SCORE - NEGATIVE FACTORS	TOTAL SCORE - POSITIVE FACTORS	TOTAL COMBINED SCORE
PRIORITY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	-	+	
PRIORITY SCORE	39	41	42	43	49	50	52	56	64	65	70	70	71	73	77	79	83	83	88	97	102	118	121	130	131	135	-	+	
"DO NOTHING" ALTERNATIVE	0	=	-	=	=	=	-	-	0	0	++	=	0	-	=	0	-	-	=	+	+	=	0	-	++	=	.392	.064	-.328
ALTERNATIVE I Modernized System	+	0	0	-	0	+	0	0	+	++	-	0	0	0	+	-	0	+	0	+	+	-	+	=	-	-	.089	.145	+.056
ALTERNATIVE II Expanded System	++	+	+	0	0	+	++	+	+	++	=	++	+	+	++	+	+	++	+	+	+	0	++	=	=	0	.059	.401	+.342

Key: ++ Very positive, + Positive, 0 Neutral, - Negative, = Very Negative factors, the group ranked the criteria in decreasing order of priority, i.e., the most important factor first.

The team's calculations were based on the impacts of the alternatives on the various actors. The alternatives' financial, operational and social attributes were used to describe these impacts. The evaluation matrix can be used to determine which alternative performs best in terms of the variables selected.

As mentioned above, users, operator, community and government all have an important stake in the success of the transportation system. However, their interests are far from identical. Some of the variety of their concerns are shown in Figure 11-2.

Figure 11-2

Urban Transportation Actors & Issues

Viewpoints	Issues	Measures
PASSENGER	* Service availability	Station/line mile, % of residents/mile
	* Passenger convenience	Waiting time, travel time saved, coordination
	* Reliability of service	On-time performance
	* Safety & security	Incidents/1000 passengers, accidents/mile, etc.
	* Cost of travel	Fare structure, cost, waiting time, etc.
	* Passenger comfort	Noise level, air quality, etc.

Figure 11-2

Urban Transportation Actors & Issues
(Continued)

Viewpoints	Issues	Measures
OPERATOR	* Subsidy required	Gap between revenues and expenses, etc.
	* Operating cost	Cost per mile, cost per passenger, etc.
	* Efficiency	Trips per hour, passengers per train, etc.
	* Safety & security	Miles between accidents, property damage, etc.
	* Capital cost	Cost per mile, cost per passenger, etc.
	* Ridership	Passengers per day, trips per hour, etc.
	* Revenues	$ per year, $ per car-mile, etc.
COMMUNITY	* Social impact & equity	Impact on community, social, interaction, etc.
	* Regional attractiveness	
	* Joint development	New development
	* Regional integration	
	* Economic impact	Employment created, dollar cost
	* Network coordination	Transfer points
	* Environmental impact	Air pollution, noise pollution, land disturbances . . .
	* Traffic impact	Congestion, travel time, waiting time . . .
	* Construction impact	Land disturbances, land use changes.

Figure 11-2

Urban Transportation Actors & Issues
(Continued)

Viewpoints	Issues	Measures
GOVERNMENT	* Subsidy required	$ per year
	* Return on investment	Revenues/year
	* Regional attractiveness	
	* Joint development	New development
	* Regional integration	
	* Economic impact	Subsidy required, jobs created, etc.
	* Local politics	Who pays, how much, from what sources, etc.
	* State politics	Money spent, subsidies, implications
	* Federal politics	Money spent, subsidies, implications

Looking at the points of view of the four main actors, the user's is perhaps the most obvious. The user directly affects and is affected by the system. The user's viewpoint is very important, and while it has often been neglected, successful transportation plans and systems always keep it in mind. Attempts have been made to incorporate public participation in transportation planning in many places worldwide, but unfortunately not all of these have succeeded.

Users contribute time, out-of-pocket costs (including operating costs for automobile owners), risk of accident, and personal effort. For all this, they receive transportation, whose convenience and comfort are factors of their inputs, the time and place of travel, the infra structure in place and the local geography.

The operator of a metropolitan transit system also has an important direct impact on the system. The operator provides the capital and operating costs to run the service. In return, users pay fares to cover some of the costs, while governments provide subsidies to pay for the rest.

The community at large is obliged to take an overall stand regarding the region's transit system. The community at large includes the users and the operator, but also includes non-users, who may not feel such a strong stake in the system as the other two. Sometimes, the community at large may be expanded to include future as well as present inhabitants of the region.

The various levels of government--federal, state and local, have become increasingly important in recent decades, as the growing deficits of transit services have required the transfer of their operation from private companies to public agencies. Governments are asked to provide grants, subsidies and loans, as well as fund research, planning and administration. Since transit is an essential public service, making substantial demands on the public purse, any serious evaluation must take into account the views of the various governments involved.

The evaluation matrix presented in Figure 11-1 shows the advantages and disadvantages of the alternatives according to twenty-six evaluation factors chosen by the group, based on the points of view of the four main actors. The team then placed these factors in order of priority, as shown by the number in the priority score row at the top of the matrix (the higher the number, the lower the priority). Each member was asked to rank the factors in order of priority, so the matrix reflects an "average" of the team's thinking.

Using a combination of discussion, consensus and voting, the team rated each alternative on all criteria. Each alternative was judged relative to the other alternatives for every criterion. Scoring was expressed along the following continuum: ++, very positive, or (+2); +, positive, or (+1); 0, neutral, or (0); -, negative, or (-1); and; --, very negative, or (-2).

The total score for each alternative comes from multiplying the inverse of the priority score by the score of each evaluation factor. The evaluation factors are placed in the matrix in order of declining priority, i.e., the judgments decline in importance the further one reads to the right.

11.2 Recommendation

The study team has sketched out two possible futures for the Philadelphia area's commuter rail network: Alternative I, a pared-down but much more efficient system, and Alternative II, using the same technology as Alternative I, but with new lines serving circumferential as well as radial trips. A third alternative has also been considered for evaluation purposes: a "do-nothing" alternative consisting of an extrapolation of present tendencies.

In arriving at its recommendations, the study team did not in fact use one or another of the various formal evaluation techniques, but instead discussed the various "pros" and "cons" of the alternatives over a span of several weeks. The evaluation matrix above (Figure 11-1) was in fact not a final product but rather a gauge of the group's thinking. The team believes that in terms of the overall benefits to the region, both Alternatives I and II are preferable to the "do-nothing" alternative, and that Alternative II is more desirable than Alternative I. A continuation of current trends is not acceptable, for it prolongs the present hemorrhage of vital capital stock. Alternative I offers a positive future, but Alternative II's economic and other benefits are so much greater still that they more than offset the higher levels of investment required.

A philosophical base underlying the team's thinking is a change in orientation from that of much of the transportation planning which has hitherto taken place in the region. Instead of reacting to trends, the group proposes a transportation network which will not only anticipate but will even help shape the region's future. The group hopes that a smoothly-functioning system will reduce much of the current "crisis management" climate, and instead allow transportation planners to plan seriously for the future.

11.2.1 Rationale

Without going into a quantitative cost/benefit analysis, it is still possible to explain the group's consensus about Alternative II in cost/benefit terms. Both the costs and benefits of the alternative may be broken down into six categories: economic, social, environmental, transportation, political-institutional, and land use. These will now be examined in turn, first in terms of system costs and then in terms of system benefits.

Starting off with the economic costs, Alternative II is clearly the most expensive to build, with its $3.35 billion investment (in 1982 dollars; about $1.1 billion more than Alternative I). Also, its operating costs will be higher than for the other alternatives, since more trains will be operated. Its social costs are low, since it does not disrupt desirable social patterns. In environmental terms, it will be the most environmentally disruptive in its construction, and once it is in service, it will result in more automobile congestion and resultant air pollution because of its numerous stations and popular service. Its transportation costs are similarly the highest, because its construction will cause the most disruption to the existing transportation systems, both transit and highways. Also, it will require the re-routing of many bus services and an increase in their frequency, thus disorienting present riders and increasing bus operating costs.

In political and institutional terms, Alternative II must jump high hurdles. Few governments will be enthusiastic about paying for it. Also, there may be institutional problems in bringing about the degree of regional cooperation necessary in order to coordinate land use policies with the system. Finally, many local communities may object to the various joint development projects at the stations.

Despite these high costs, Alternative II also offers the most benefits. In economic terms, Alternative II clearly does the most to make the Delaware Valley competitive with other metropolitan areas. In incremental terms it offers the best return on investment, and costs the least to operate per passenger-mile. It will divert more automobile users to transit, and thus save the most energy. It maximizes mobility by providing direct transit access for suburb-to-suburb as well as city-to-suburb travel. It enables businesses to draw from a larger pool of both employees and customers, and facilitates reverse commuting, to an extent which Alternative I simply does not match. It will help revitalize other areas throughout the Delaware Valley. The joint development should create such a positive image of the system as to cause real estate developers to associate the system with successful development. Finally, along with Alternative I, it will make the area easier for tourists to get around and thus make their stay more pleasant.

By maximizing mobility for the residents of the area, Alternative II will provide the greatest social benefits as well. People will be able to reach more shopping and employment areas without having to own a car, to a much greater degree than would be possible with Alternative I. And by diverting the most automobile users to transit, it will also do the most to reduce air pollution and thus improve the environment.

Alternative II has major transportation benefits. It helps create a truly regional transit system. With proper routing and scheduling, the integrated transfers will make Philadelphia's transit network a leader in North America.

Suburban buses will have less of a line-haul function and will increasingly be feeders to the regional rail network. In this fashion, each mode will serve the function to which it is best fitted, resulting in optimum service to users at minimum operating cost.

In the political-institutional realm, Alternative II will do the most to bring the different parts of the region together. This coherence is due to its more equitable distribution of benefits. By improving the Philadelphia area's competitive position in the Northeast, the system will help reduce the unproductive city-suburban tensions, and instead channel the region's political energies from confrontation to cooperation based on common interests.

Finally, Alternative II will do the most to bring about the flowering of the multi-purpose centers throughout the region. By encouraging development in already urbanized areas, it conserves farmland and reduces the public cost of accommodating new development, because the streets, schools and sewers are there already. Combined with local development plans such as proposed in Chapter 2, Section 3, the results could be so attractive for living and working that the land use benefits of the system would overshadow the others in the public eye.

11.2.2 Organizational Proposal

It must be recognized from the outset that the team did not have time to conduct a proper study of the management and institutional issues involved with either Alternative. The group was not able to properly consider questions of who is to finance, build and run the system, who establishes policy, or what sort of inter-county (to say nothing of interstate) structures may be desirable. Clearly, such an investigation is necessary for a thorough understanding and evaluation.

Given, then, that there are many possible institutional approaches, the group believes that the setup outlined below offers one good way to manage the system's construction and operation. However, there are many other possibilities which should also be explored in detail.

This approach, which initially seems quite attractive to the team, centers around the creation of a Regional Rail Development Authority (RRDA). The RRDA would be set up as part of a cooperative agreement among the five counties (Bucks, Chester, Delaware, Montgomery and Philadelphia). All the parties should sign an agreement, legally binding, whose terms should cover no less than the time it takes to complete the system, preferably it should not expire until the last bond has been paid off. The state should either be a direct signatory party to the agreement, or else should pass a law enabling it to cooperate with and help fund the RRDA. The Authority should be created by state law.

The cooperative agreement would spell out precisely:

1. Financial contributions required from each participant
2. Organization of the Authority
3. Voting powers
4. Action and responsibilities for planning and construction.

The RRDA would be responsible for planning and building the system, but not necessarily for its operation. Often it is a good idea to remove the strategic planning functions of such an agency as the RRDA from the daily problems of operation, so that the latter functions do not overshadow the former. Operations could be turned over to another agency, probably SEPTA. The RRDA could either hand over each line to the operating agency as it is completed, or hand over the system as a whole when it is finally completed (assuming that RRDA does not operate it directly).

The RRDA will formulate, but not carry out land use policy. Each of the five counties will, as part of the cooperative agreement, set up a Land Use Authority (LUA). Following the land use policy guidelines enunciated by the RRDA (and agreed on by its constituent counties), each county LUA will make specific land use plans for each station. These Plans will have to be approved by the RRDA. Each LUA will have jurisdiction within 2000 feet of every station. (If new stations are put in service, either on existing or new lines, the LUA's will have jurisdiction there as well).

Each LUA will have the joint development functions described in Chapter 5. In order to implement the land use plans for the stations, each LUA will assume the power of zoning for 2000 feet around each station. All planning approvals and building permits in these areas will be channeled through the county LUA's, rather than the local governments.

It is important to understand that what is being proposed here is only a change in land use administration. The land will otherwise remain part of the community in which it is located, and that community will still collect the property taxes on it. Any increase in property values caused by the system could be shared with the county LUA through a Value Increment Tax as described in Chapter 5, according to the principle of sharing the system's financial costs among its beneficiaries.

Whatever institutional structure is chosen, it will be necessary to find a democratically acceptable balance between local and regional needs. The agencies created must be able to accomplish what they have been created to do, but must not be allowed to run roughshod over the community in the process. An institutional structure based on the federal model, with a division of powers, may well be able to strike just such a happy medium.

CONCLUSION

by The Entire Study Team

In its investigation of the problems of the Philadelphia area's commuter rail system, the study team has come up with two major alternatives for the year 2000, both of which involve transforming the present service into a modern regional rail network. However, the underlying philosophies of the two are quite different.

Alternative I, the Modernized System, is based to some degree on an extension of existing trends. It proposes a somewhat smaller, but much more efficient network. Alternative II, the Expanded System, is based on a high level of coordination between transportation policy and land use policy, as expressed in the Multi-purpose Centers concept. It proposes a network serving circumferential as well as radial trips, which is expected to attract very high levels of ridership.

The same technology is proposed for both alternatives. Two levels of service are projected: commuter rail and regional rail. These differ only in terms of service frequencies, with regional rail providing more frequent service than commuter rail. Nevertheless, they share the following technological elements:

- High level platforms at all stations

- Automatic fare collection at all stations
- One-person operation of all trains
- Automatic train control on the busiest sections of track
- Automatic driving of trains on the busiest sections
- New 85' cars, seating 98, with room for 47 standees, 2 x 2 seating and 3 double channel doors per side
- Retrofitting of Silverliner IV cars with provision to automatic driving, center doors, and replacement of present 3 x 2 seats with 2 x 2 arrangements.
- Closed-circuit TV surveillance of stations

Two phases of implementation are foreseen for Alternative I. The first involves the provision of commuter rail service at stations with high-level platforms; the second involves a full conversion of most lines to higher-frequency regional rail.

The following lines are to be upgraded to regional rail (except as noted):

- Airport (commuter rail only)
- Chestnut Hill West
- Fox Chase (commuter rail only)
- Lansdale-Doylestown (regional rail frequency

to Lansdale, commuter rail beyond Lansdale to Doylestown)
- Media-Elwyn
- Norristown (to be extended to King of Prussia)
- Paoli
- Trenton
- Warminster

And a new regional rail line is to be built on existing rail right-of-way from King of Prussia to Fort Washington on the Reading-Lansdale line, via Norristown.

Alternative II is primarily distinguished by a Chester-Trenton circumferential line. The line starts at Chester and follows an abandoned rail right-of-way to Lenni, where a connection is made with the Media Line. At Lenni, the line takes the existing West Chester Line to West Chester. It continues north to Frazer, connecting with the Paoli Line. Then it proceeds on a new alignment to join the Reading Chester Valley Branch. To reach King of Prussia, the line proceeds through a short tunnel which will be built directly under the shopping mall. Once beyond the tunnel the line follows the right-of-way of an existing industrial track to join the Reading's Pottstown main line, which it follows to Norristown. Southeast of Norristown, the line rejoins the Trenton Cutoff, which it follows to the Reading Lansdale Line. At this point, the line turns south and joins the Reading main line. At the three-way junction south of Glenside, the line turns northeast and follows the Reading's West Trenton line to Oxford Valley Mall (Woodbourne), where it takes the Penn Central's Cutoff once again. It then joins Amtrak's Northeast Corridor, terminating at Trenton.

Another completely new service is to be provided on a Greater Northeast Philadelphia line, proceeding from Holmesburg Junction on the Trenton line via industrial rail rights-of-way past the Northeast Philadelphia Airport and along a short section of new right-of-way to the Reading's New York Short Line, which is joined to Neshaminy Mall, where it joins the West Trenton line section of the circumferential line. Shuttle service is proposed between Holmesburg Junction, Neshaminy Mall and Oxford Valley Mall. Changes to radial lines are as follows:

- Media line service is to be extended to Lenni, where connections will be made to circumferential trains. Rather than serve Elwyn, the line will take a new right-of-way to serve Granite Run Mall.
- Paoli line is to be extended on existing trackage to Frazer, where it will connect with the circumferential line.

The proposed fare structure is based on two governing principles:

- Fares are based on distance travelled, with the mileage charge declining as distance increases.
- Different fares are charged for different travel markets, so that off-peak fares are 30 to 40% cheaper than rush hour fares. Frequent riders are charged slightly less per trip than occasional travelers. A variety of discounted incentive fares are provided.

For the initial phase of Alternative I, annual revenues are estimated at $88,889,490, and for the second phase at $138,048,140. These sums will cover 58% and 68% of operating expenses, respectively. For Alternative II, farebox revenue is projected at $226,011,630, which amounts to 79.8% of operating expenses.

To promote more efficient operations, the group recommends a series of measures which includes:

- Enhanced intermodal connections
- Improved passenger information
- More aggressive and innovative marketing
- Drop-back crewing

In addition to reducing fleet size and crew requirements, these measures should also reduce overall operating costs.

Rapidly evolving demographic trends in the Delaware Valley made it necessary for the team to produce its own estimates of year 2000 population and employment in order to determine total person-trips. In the final formula, the projected population declines for Philadelphia and Delaware counties were distributed to the other area Delaware Valley counties based on their 1980 regional population shares. Once it was completed, factors for home-based-work and H-B-W rail trips were added. Then the coefficient was multiplied on the 1977 DVRPC Total Person trips district matrix and catchment areas were marked along each alignment. Once the district percentages were estimated, they were multiplied by the home-based-work rail district trips, producing daily ridership counts of 240,500 for Alternative I and 377,000 for Alternative II.

The group's proposals for financing this project are similar to our overall approach to the project. They are exploratory. The conclusions and recommendations are as follows:

1. The integration of all feasible means of paying for the system is crucial to the viability of the project.
2. Securing Federal matching grants appears to be the most painless financing approach for the local community.

3. A financing arrangement involving accumulation of present subsidy funding while temporarily providing alternate less costly express bus service is feasible.
4. A dedicated revenue source involving value capture through property taxation appears feasible. Specifically, a Value Increment Tax is recommended.
5. Dedicated revenue sources involving a sales tax, motor vehicle tax, or payroll tax are not recommended due to their tendency to be socially inequitable and politically and legally troublesome.
6. Sophisticated borrowing techniques should provide additional critically needed capital, as well as a means for facilitating amortization.
7. Supplemental sources of revenue involving additional funds from the State Lottery and sale of unnecessary railroad and government property, as well as joint development, could help reduce the financial burden of the community.
8. Equipment leasing techniques such as Safe Harbor Leasing and issuing Equipment Trust Certificates

could also help reduce the financial burden on the community.

9. Operations costs must be equitably distributed among users, non-users, and Federal, State, County and Municipal governments.
10. Community enthusiasm and support for the project may be enhanced through the use of novel financing methods such as a new transit mini-lottery, unique user services, street musician areas and the rental of station concession and advertising space.

The capital cost of Alternative I is estimated to be around $2.25 billion in 1982 dollars; Alternative II's price tag is about $3.35 billion. In its first, commuter-rail-only phase, 30,645 thousand car-miles will be operated at a cost of $153,225 thousand per year. In its final, regional rail phase, Alternative I calls for 57,519 thousand car-miles, which will cost $201,316½ thousand to operate. Alternative II will provide 80,889 thousand car-miles of service per year, which will cost $283,111½ thousand to provide.

For evaluation purposes, the study team examined three alternatives: Alternative I, Alternative II, and a "do-nothing" alternative (involving no further investment in the system). The "do-nothing" alternative was rejected on the grounds that it would lead to further decline and eventual abandonment of the region's rail system, a potentially valuable but underutilized resource.

Alternative I is preferable to the "do-nothing" alternative, since it improves service and ridership considerably. However, given the fact that both Alternatives I and II have great capital costs, Alternative II is preferred on the grounds that the additional benefits it offers over Alternative I are much greater than the additional cost.

Alternative II is expected to:

- Do the most to improve the Delaware Valley's competitive position with regard to other Northeastern metropolitan areas
- Enable businesses to draw from a large pool of employees and customers
- Maximize mobility throughout the region without having to own a car
- Help create a well-coordinated transit network
- Allow both rail and bus to specialize in the sort of transit services to which each is best adapted
- Distribute benefits throughout the region and help reduce city-suburban tensions
- Promote coordinated transportation-land use developments, encouraging growth in already-urbanized areas where infrastructure is already in place.

APPENDIX I

TECHNOLOGY CHARACTERISTICS

by John Allen, Peter Bromley and Carmen Blassini

In order to select optimum system technologies, it is necessary to know what are the requirements and benefits of each possible alternative. This appendix is a synthesis of the technology work group's memoranda on the subject, summarizing the pertinent facts about light rail, rapid transit, commuter rail and regional rail transit. For these purposes, the Media-Sharon Hill lines of SEPTA's Suburban Division may be taken as a good example of what is meant here by light rail, the Broad Street Subway for rapid transit, the present commuter rail system for commuter rail, and PATCO's Lindenwold Line as an example of regional rail. Each system is described in turn under a series of subject headings.

Train length: The minimum light rail train consists of only a single car. Normally the minimum train length is two cars for the other modes, but single-car operation is occasionally possible on these as well. Maximum train length for light rail is usually three cars (occasionally four). For rapid transit and regional rail, maximum train length is six or eight cars, occasionally 10 (e.g., New York). Commuter rail maximum train lengths varies from six to twelve cars, depending on the system. The determining factor for all these modes is platform length.

Car dimensions: Typical light rail car lengths are 46' for 4-axle cars, 65' for 6-axle, and 87' for 8-axle models. Normally, 8' is a typical width. Rapid transit car dimensions vary widely--from 55' by 9' on the Market-Frankford line to 67' x 10' on the Broad Street Subway. The latter is usually considered large for old, established systems. In the 1960's, Toronto developed a 75' subway car, and such regional rail systems as BART, Washington and Atlanta have chosen similarly long vehicles for their operations. Commuter rail cars are almost always 85' long. Both regional and commuter rail cars are 10' wide, the standard American railroad car width.

Passenger capacity: A four-axle light rail car might seat about 50 riders, with room for as many standees with these proportions being extended as additional trucks and articulation joints are added, increasing the car's length and capacity. For rapid transit, the Market-Frankford cars have 55 seats and can accommodate up to 150 standees under crush load conditions. Corresponding figures are 62 seats and 170 standees for the new Broad Street cars. Philadelphia's latest commuter rail cars seat 129 passengers in 3 x 2 seats; if center doors are installed eight seats will be lost. Commuter rail lines are reluctant to supply standing capacities of their cars for fear it would demolish the myth that every rider finds a seat on these premium-fare services. The Washington Metro regional rail cars seat 80 and can load up to 160 standees.

Dynamic characteristics: Light rail cars tend to have high acceleration/deceleration rates but moderate top speeds. Acceleration of 3 mphps or more is quite normal for 4-axle cars (less for 6 and 8-axle vehicles) but top speed is rarely over 50 mph. Rapid transit acceleration rates range from 2.5 to 3 mphps or more, with top speeds of 50 or 60 mph. Commuter rail acceleration and braking rates are low--1.5 and 2 mphps respectively for Chicago's new South Shore cars--but top speeds are high, from 65 to 85 mph. Regional rail cars accelerate swiftly (4.25 mphps on Lindenwold Line and Washington Metro) and routinely cruise at 75 mph.

Geometric restrictions: Light rail cars can operate through severe grades and curves. They can climb a 15% grade, although 8 to 10% is the maximum recommended. They can take 80'-radius curves comfortably and have even been known to handle 43' curves. On the Market-Frankford rapid transit line the minimum curve radius is a tight 95', with maximum 5% grades. Many newer rapid transit systems are much less demanding; Toronto's tightest curve is 400 feet.

On the BART regional rail system, the minimum curve radius is 492 feet and the steepest grade is 4%. Commuter rail, if anything, is even gentler than regional rail; outside of the new Center City Commuter Connection tunnel, there is scarcely a grade in excess of two percent on the entire SEPTA commuter rail network.

Right-of-way: Light rail can operate on a wide variety of rights-of-way, ranging from city streets to subways, but reserved line with grade crossings is typical. Rapid transit and regional rail require exclusive right-of-way because of their frequent operations and high speeds. Commuter rail, however, can be operated on any track where mainline passenger and freight trains can go, resulting in some flexibility.

Stations: Light rail vehicles can stop anywhere for passengers. Most light rail cars can only use low platforms. A few (Calgary, Edmonton, 69th Street-Norristown) use high platforms only, and San Francisco's Muni Metro cars use both kinds. Commuter rail cars exhibit similar diversity. Most Chicago cars use low platforms only, while New York's Long Island and Metro-North cars can only serve high platforms. Philadelphia's cars serve both kinds, using a cumbersome trap door system based on long-distance railroading practice.

Service levels and system coverage: Light rail provides moderate coverage of inner suburban areas, with a maximum capacity from 6,000 to 20,000 passengers/hour. Rapid transit provides coverage along the historically busiest corridors, with a capacity from 10,000 to 40,000 passengers/hour. Commuter rail provides service to outer suburban areas, with a capacity from 8,000 to 15,000 passengers/hour. Regional rail occupies an intermediate niche between traditional rapid transit and commuter rail coverage, with maximum capacity around 30,000 passengers/hour.

Relationship to other modes: Light rail has good connections with other transit lines both downtown and outside the central area, with park and ride at some outlying stops. Rapid transit has good connections with other urban transit lines, but some of the newer, outer stations have park and ride. Usually, outlying commuter rail stations have park and ride but poor connections with other transit services; however, there are usually excellent transit connections available downtown. As with service and coverage, regional rail occupies an intermediate range between commuter rail and rapid transit.

Advantages: Light rail can be used on a wide variety of rights-of-way, at minimum capital cost. Rapid transit is a high-capacity mode which can be incrementally expanded from existing lines. Commuter rail is easy to set up, operate and modify if needed. Regional rail provides good, fast service at low operating cost.

Disadvantages: Light rail operations tend to be slower and possibly less comfortable than other modes. Rapid transit requires very high passenger volumes to justify the construction of exclusive right-of-way. Commuter rail service is very expensive to operate because of large labor input and inefficient use of capital stock in operations. Regional rail requires not only private, grade-separate right-of-way, but also needs expensive automatic train control and (usually) automatic fare collection.

APPENDIX II

FARE COLLECTION SYSTEMS

by John Allen

Ticket sales and inspection methods are very important to the smooth and economical functioning of a rail transit line. Though seemingly not an integral part of the basic rail technological package, fare collection is nevertheless critical to any system's satisfactory performance.

This appendix examines the technologies of ticket sales and fare collection currently in use on North American and European rail transit lines. Each method is described, and its advantages and disadvantages discussed.

Flat fare-turnstile: On most North American and a few European rapid transit systems, access to station platforms is controlled by a series of turnstiles whose gates are released when the proper fare is being inserted. The turnstile may accept coins (NY-PATH), tokens (NYCTA, Rome, Toronto), or tickets (Paris). More recently, systems have developed turnstiles capable of accepting several methods of payment. Thus, Boston's turnstiles accept tokens and magnetically-coded one way tickets, and Atlanta's accept cash fares, transfers and passes. Some of the more traditional systems (Philadelphia, Chicago) require all passengers presenting or requesting transfers to go to the agent's booth (although a few Chicago turnstiles allow cash fare passengers to get their transfers from the machine while paying their fare). San Francisco (MUNI Metro) and Atlanta riders may also get a transfer from the turnstile, while Toronto, Montreal and Washington issue them from automatic push-button dispensing machines (accompanied by warnings that it is against the law for a passenger to take more than one!)

This method is fine for networks of limited radius from the city center, but beyond, say, five or ten miles it becomes desirable to collect zone fares. Boston, at its Quincy-Braintree branch stations on the Red Line, requires departing passengers to deposit the zone charge as they pass through the turnstiles leaving the station. Inbound passengers pay the total of the base fare plus the zone fare, but can request a receipt from the station agent. At their exit station, instead of paying the zone charge to pass through the exit turnstiles, local riders go to the agent's booth and exchange their receipt for a cash refund. This method may be satisfactory on a single branch line with one extra zone charge, but would not be very efficient on a more complex system.

Manned ticket inspection: A cumbersome system, manned ticket inspection requires a station attendant to check the tickets of all passengers at both their arrival and departure points. Although still used on some European systems (London Underground being the most glaring example) only one North American system (Toronto's GO Transit) uses it. Tickets can be sold either by ticket agents or by vending machines.

Besides entailing huge labor costs, manned ticket inspection is also singularly vulnerable to fare evasion ploys which can cost a system dearly in lost revenues. It is much cheaper for a passenger traveling between two distant stations to use two different single-zone tickets for the local zones of his origin and destination stations. At both his origin and destination points he may thus palm himself off as a short-distance rider, with little risk of ever being caught. London Transport is converting its manned ticket inspection system to an automatic revenue collection system, and is justifying the expense largely in terms of savings from reduced fraud.

On-board fare collection: This is the most traditional and common of fare collection systems. There are two basic variations: payment can either be made upon boarding and/or leaving the vehicle, or it can be made to a roving collector who takes fares from passengers at their seats.

The first method is generally used on buses, trolleybuses, streetcars and light rail vehicles. Usually passengers deposit a flat fare in the farebox (using exact change, token or ticket) or hand the driver a valid transfer upon boarding. Extra charges for additional zones crossed are collected as passengers get off in the outbound direction. Inbound, passengers pay the base fare plus any applicable zone charges. A few systems, such as Philadelphia's Suburban Division (ex-Red Arrow), and Pittsburgh, collect fares from outbound passengers as they leave the vehicle. Passengers are expected either to provide themselves with exact change in coins or to have bought tokens or tickets (New York, Pittsburgh, Montreal, Toronto) at stations or other sales locations.

The second method is generally used on most commuter rail systems in North America. A conductor or trainman inspects passengers' tickets at their seats. Usually, passengers are required to leave their tickets on display, and most commuter rail cars have special ticket-holding clips for this purpose. The conductor punches single tickets, and generally removes them when the train arrives at the destination zone. Monthly and weekly passes are left on display in their clips, and their holders take them with them when they get off the train. Conductors will sell single tickets when passengers board the train at stations without ticket agencies or whose agencies are closed. To encourage passengers to buy tickets at ticket windows whenever possible, however, a penalty surcharge is collected when passengers pay cash fares from stations whose ticket offices are open. As a security measure to protect its conductors, the Illinois Central Gulf Electric has established penalty surcharges when passengers boarding at non-agency stations offer a banknote of ten dollars or more in payment of a single cash fare.

With the first method (paying the driver), the major advantage to the transit agency is that it ensures every passenger will pay the proper fare. The problems are that it is complicated to enforce in a multi-zone fare system, and that the process of fare payment itself is time-consuming, thus slowing down vehicle operations by extending time at bus and car stops.

With the second method (conductors checking passengers' tickets) the advantage is that little or no fixed capital installations are required. This method may be acceptable for lightly-traveled lines with infrequent service. However, there are distinct diseconomies when this method is used on heavily-traveled lines with frequent service. This fact explains the interest such newer systems as San Francisco's BART, Philadelphia's PATCO and the Washington Metro have shown in automatic fare collection.

Honor system: Many, perhaps most European transit systems have switched from older methods to the honor fare system, and it has begun to gain a foothold in North America. Vancouver introduced the honor system to North America with the introduction of its "Sea-Bus" ferry service. Edmonton, Calgary and San Diego have adopted it for their new light rail lines. In 1982 Tri-Met in Portland introduced the honor system throughout its bus network, and the province of Quebec plans to bring it to Montreal as part of its proposed restructuring of the transit system there.

The honor system is perhaps the simplest of all fare collection systems. Passengers are responsible for seeing that they have the proper ticket in their possession. They may buy single, multi-ride, or unlimited-ride tickets, from vending machines or ticket agents (on some systems drivers sell tickets, and sometimes at a higher fare to encourage pre-purchase). If a zone fare system is used, passengers may buy either local or multiple-zone tickets. Once they have obtained the proper ticket, they validate it in a machine located either on board (for buses and street-cars) or at the station (for most light rail, rapid transit, commuter and regional rail systems). Once validated, the ticket is good for unlimited travel, but only during a set period of time within the zones for which it was purchased. For example, a ticket might be good for

60 minutes in the first zone and for 30 minutes in each additional zone. Stopovers and even return trips are allowed so long as the ticket is neither out of time nor out of zone.

There are no physical barriers to entry, either to vehicles or to station platforms. Fares are enforced by roving ticket inspectors. According to the city and the hour, these may be either uniformed or plainclothes personnel, working alone or in teams. Generally, the inspectors make random, spot checks throughout the system (though concentrating on areas where it is believed that fare evasion is highest). Inspectors board a vehicle and ask each passenger to show a valid ticket. Passengers traveling on improper tickets or without any ticket at all are either fined on the spot if they can pay, of if they cannot, their case is turned over to the transit agency's legal department (and collected through the courts, if necessary). Generally the fine is from ten to twenty times the single fare, which is usually a strong deterrent to would-be fare evaders. Evasion rates in the late 1970's ranged from about one percent in Bern, Switzerland to nearly 10% in The Hague, although a more intermediate figure seems to be typical. In several countries, records are kept on fare evaders and repeat offenders are fined more heavily than first-time offenders.

The honor fare system is obviously quite attractive to many European and a few North American transit properties. Its advantages are obvious: boarding times at stops can be speeded up; drivers, now freed from the bother of collecting fares, can concentrate on driving; and more entrances and exits can be installed at rail stations since access control is no longer a problem. Its disadvantages are somewhat more subtle: enforcement of the honor system requires a special staff of ticket inspectors, who must be able to make their presence felt throughout the system, at all hours that the system is in operation. Although the honor system has worked well wherever it has been tried, some American systems are probably uncomfortable even considering the idea. General standards of behavior in several American cities, and a seemingly low level of respect for public property in particular, have doubtless led many transit agencies to the conclusion that were they to try to implement the honor system, an excessively high level of enforcement might be required to hold evasion to acceptable levels.

Automated revenue collection: Automated revenue collection is the most sophisticated fare collection technology, and is generally associated with modern regional rail systems. It enables zone fares to be collected efficiently at a large number of stations. The prototype installation in North America was on a Chicago commuter line (the Illinois Central Gulf Electric in the mid-1960's) and was the model for PATCO's Lindenwold Line machines in Philadelphia. These two sell single and multiple-ride tickets, with validity between zones chosen by the passenger when buying the ticket. The ARC systems for San Francisco's BART and the Washington Metro are broadly similar, except that they allow passengers to buy farecards of varying denominations and use them as they please until the monetary value is exhausted, rather than offer zone-to-zone tickets.

Systems of the Chicago-Philadelphia design provide prospective travelers with vending machines for most ticket purchases. At the main downtown stations, and a few outlying stops on the Chicago line, ticket agents are in attendance to sell monthly tickets, but at some stations their presence is no longer justified and they have been replaced with vending machines which sell one-way, round-trip and weekly ten-ride tickets to all zones. Dates and zones of validity are magnetically and visually imprinted on the ticket at the time of sale. On Philadelphia's PATCO, there are several machines, each selling only two different zonal varieties of one-way tickets. (Weekly ten-ride tickets are available from newsstands). Since the vendors only take exact change, there are bill-changing machines. Passengers on both systems put their ticket through a slot in the turnstile as they enter and exit. At the exit, the machine retains tickets which are not good for additional rides. Passengers who wish to ride beyond the validity of their tickets or have other problems can get in touch with the central control using specially marked "call-for-aid" phones near the fare gates.

The Washington Metro and BART use the so-called farecard system, whereby passengers purchase tickets of a monetary value of their own choice. The vending machines allow selection of any value from the minimum fare up to $20.00 (Washington Metro gives a 5% bonus on purchases of $10.00 or more). The passenger inserts the farecard both upon entry and exit. If the farecard is still valid, the remaining value is magnetically encoded and visually printed, and returned to the passenger. If the ticket has less than the required value the passenger can go to an "Addfare" machine which will re-encode it for the proper amount upon payment of the difference. There are also machines which will issue a new farecard of identical or increased value when the rider has used as many transactions as can be printed on the face of the farecard.

The great advantage with ARC is that it quickly, efficiently and comprehensively checks everybody's ticket, and at the same time keeps excellent count of ridership.

It has a large capital cost, but it makes up for this over the long run with savings in operating expense and reductions in ticket fraud.

ARC is, as noted above, usually restricted to regional rail systems. One problem with ARC is ticketing integration with connecting transit services. In Washington one finds the ironic situation that bus-to-bus and Metro-to-bus transfers are issued free, but that passengers changing from the bus to the Metro must pay an additional fare simply because there is no provision for the ARC system to accept bus transfers! Montreal and Atlanta use punch-coded transfers for use in rapid transit station turnstiles, but then those cities have flat-fare systems. Theoretically, it should be possible to design a regional rail ARC system that accepts Montreal-style transfers issued with punch-coding as partial payment of fare, reads the transfer for its time limit, and encodes a corresponding time limit on the regional rail ticket, but it seems that this has not yet been tried.

APPENDIX III

SCHEDULING

by Peter Bromley

Scheduling entailed taking ridership projections as generated and applying a factor representing peak hour ridership at the maximum load point as a percentage of average daily travel for each line. The resulting figure was multiplied by a factor of 1.5 to simulate the effect of the "peak" within the peak hour. Headways for each line were determined from the formula

$$\frac{60 \times C_v \times a}{P} = n \times h$$

where C_v is the vehicle capacity (assumed to be 181 spaces)
a is the load factor desired (0.8)
P is the maximum peak load
n is the number of cars per train
and h is the headway in minutes.[1]

This presented the group with a range of different headway and train length options. With the Center City Commuter Connection in existence, routes had to be paired in ways which satisfied demand on all lines but which minimized over-capacity. In addition, some attention was paid to origin and destination desires.

Fleet requirements are derived from the following formulas:

$$T = 2\,(t_o + t_k)$$

where T is the cycle time
t_o is the running time between line ends
t_k is the terminal time

and

$$N = \frac{T}{h} \times n$$

where N is the fleet requirement
h is the headway
n is the number of cars per train.[2]

---

[1] From Vuchic, Vukan R. Transit Operating Manual, Harrisburg, Pennsylvania Department of Transportation, 1978, pp. 5-21.

[2] Ibid, pp. 5-29.

APPENDIX IV

Year 2000 Maximum Potential Ridership for Individual Alignments (Alt. 1)

Alignment	Service	Ridership Range (000)	Increase over 1982 (%)
Paoli	Commuter	20-36	8-94
	Regional	30-52	----
Elwyn	Commuter	19-32	46-146
	Regional	28-48	------
Norristown	Commuter	24-38	883-1456
	Regional	30-52	--------
KOP-Fort Washington	Regional	11-19	--------
Lansdale	Commuter	13-19	163-285
	Regional	18-28	-------
Fox Chase	Commuter	10-19	89-259
Trenton	Commuter	47-69	412-652
	Regional	68-100	-------
Doylestown	Commuter	8-12	178-317
	Regional	11-17	-------
Airport	Regional	5.5	-------

APPENDIX V

FIRST ROUND TOTAL PERSON TRIP MATRIX

1	62730	18600	6127	20947	16779	3886	4021	1252
2	711373	19781	13878	21830	24235	5471	5931	1079
3	29710	18715	36290	21661	7501	1989	1770	005
4	84587	26501	193817	15059	28558	9595	5718	3881
5	48723	17624	3967	19533	53940	21032	14392	2015
6	22086	7343	1784	9138	31309	35804	15761	2225
7	22358	8663	1673	6031	24050	15719	41522	926
8	13841	3729	1400	8965	7133	5583	2347	22722
9	23843	6066	2066	12417	15588	17700	6947	8238
10	30721	7268	2028	10148	19877	23816	14835	3866
11	39908	10500	2344	8923	20334	17453	34950	1960
12	18404	5120	1213	3956	8021	5446	10089	785
13	9584	4890	3822	3061	2024	047	687	222
14	18929	8677	9886	8896	3890	1214	1135	479
15	45813	14928	20143	27444	8959	2856	2322	1149
16	18750	4489	3978	13493	4749	2295	1376	1477
17	5196	2134	1970	2849	1175	450	353	225
18	1815	802	597	820	441	168	148	79
19	3620	914	626	1942	1085	652	403	513
20	1491	414	190	612	500	285	198	221
21	658	221	92	287	238	128	93	92
22	1411	468	275	646	447	234	182	154
23	3329	1015	733	1599	839	362	282	205
24	1016	471	287	435	259	112	104	55
25	614	193	116	262	203	116	73	65
26	648	209	124	277	221	120	101	74
27	492	241	133	210	142	60	67	29
28	243	106	68	112	84	41	36	27
29	302	140	67	118	89	40	36	27
30	5676	1226	394	1409	2275	1831	1618	658
31	3478	753	261	1073	1441	1155	806	847
32	23315	4732	1424	6326	10147	9170	7323	3665
33	6367	1402	552	2580	2228	1621	896	3084
34	31654	6872	3840	24423	9948	5830	2959	5840
35	5003	1143	473	1965	1651	1120	695	1526
36	3608	969	419	1499	1180	712	480	686
37	4088	1053	406	1359	1514	1061	806	826
38	644	215	93	267	234	131	118	120
39	946	277	120	362	310	183	136	117

40	445	137	55	157	166	104	87	66
41	524	191	70	185	198	113	124	56
42	1070	198	111	341	402	251	233	151
43	2040	516	182	545	775	547	443	269
44	594	160	60	174	222	150	133	62
45	259	70	23	73	94	60	60	26
46	5121	1201	372	1225	1912	1435	1435	494
47	688	187	59	152	234	142	187	39
48	9887	2159	543	1564	3062	1829	3372	270
49	2647	002	168	447	806	459	802	82
50	2532	621	186	469	776	424	709	82
51	4755	1057	287	774	1433	800	1466	125
52	380	145	47	104	162	83	136	25
53	359	136	42	106	140	77	121	19
54	518	185	61	140	202	108	158	28
55	234	91	30	67	100	48	77	16
56	281	113	43	88	113	53	88	18

1	2688	2645	4307	1563	700	2292	4349	1724
2	2429	2288	3820	1490	1295	3686	4124	1396
3	1162	903	1255	533	1417	6006	9386	2131
4	7016	4369	4385	1583	1298	5688	14869	7712
5	6034	5957	6564	1962	442	1346	2274	1383
6	10063	11908	9294	2224	248	732	1174	1045
7	3771	6921	20716	4124	275	708	944	668
8	11713	3954	2369	817	200	689	1261	1972
9	60128	25266	8560	2653	311	1010	1684	2045
10	32395	60263	25680	6160	330	1013	1590	1782
11	9317	23115	161155	54364	480	1225	1566	1527
12	3404	6252	511126	73112	295	704	808	778
13	447	361	602	3487	23429	37749	4379	6686
14	884	686	953	496	28947	159269	40875	17531
15	2037	1520	1850	843	7784	57436	102556	33110
16	2178	1464	1474	031	5198	21123	283732	42909
17	404	300	355	191	20196	28519	7662	14438
18	158	124	161	101	8713	4173	1526	2648
19	754	467	508	249	1408	2769	2293	40578
20	334	223	250	153	281	505	463	3457
21	146	109	133	82	153	235	194	975
22	263	186	233	153	1040	1105	646	3224
23	362	270	342	207	4384	4273	2202	9282
24	101	88	116	84	1962	1346	580	988
25	121	92	105	86	329	376	733	887
26	146	97	125	100	309	374	223	951
27	60	52	78	56	564	488	235	415
28	51	35	49	37	200	198	109	306
29	40	29	45	41	267	227	125	185
30	2881	3543	6158	15645	199	435	511	1129
31	3000	2640	2136	1924	187	397	444	1444
32	19982	24828	28089	15926	480	1374	2083	3104
33	5024	2384	1388	708	523	1240	1364	6807
34	6576	3873	3386	1263	1959	6329	13965	51704
35	2514	1467	1085	653	571	1247	1346	7169
36	1111	669	667	423	499	1050	1026	6623
37	2151	1797	1673	1848	445	854	785	2689
38	226	169	201	197	110	200	174	581
39	199	156	184	123	143	269	244	914
40	161	138	152	204	65	113	99	265
41	161	156	235	322	62	118	90	208
42	208	385	433	588	103	196	178	469
43	894	907	1127	1871	135	282	247	084
44	211	225	313	569	38	75	73	164
45	79	82	131	250	16	33	29	64
46	1945	2369	4928	14482	200	428	462	945

47	147	190	568	1716	31	65	6	95
48	1074	1669	9294	39781	235	534	589	537
49	289	428	2074	7319	87	179	187	192
50	272	381	1682	4975	99	215	195	218
51	403	577	3255	8026	139	299	306	257
52	59	76	287	726	20	36	44	54
53	66	74	287	726	20	36	44	54
54	83	101	332	737	34	56	59	68
55	40	52	161	358	16	30	29	36
56	50	54	163	313	25	49	35	54

1	388	50	223	58	8	29	58	6
2	496	55	237	50	4	17	65	8
3	742	59	268	45	7	14	69	6
4	1275	86	917	133	17	31	172	13
5	256	27	261	62	9	22	43	4
6	163	14	261	62	8	22	43	4
7	127	15	165	39	8	16	33	1
8	226	17	563	106	17	31	42	3
9	282	29	569	116	23	32	55	7
10	287	24	497	114	20	37	51	6
11	297	26	438	106	17	29	65	8
12	169	20	254	71	13	19	39	6
13	27096	4106	1680	166	32	232	1437	203
14	17498	739	1915	163	25	108	642	66
15	7430	401	2228	214	140	103	489	38
16	16247	581	22806	987	121	385	1693	67
17	76232	1952	3007	212	37	260	1967	108
18	10602	29204	1410	182	34	539	6403	1013
19	4417	387	128169	5115	407	3036	5698	78
20	576	93	10945	58070	6021	1821	1221	39
21	251	55	2217	9916	27741	1297	606	33
22	2216	817	13718	3486	1023	77349	22317	895
23	12894	6067	21287	2260	354	132523	140433	1954
24	1889	3603	902	190	45	1311	6375	51815
26	493	152	2786	1158	1728	8028	2097	158
27	504	456	402	96	31	520	1374	6915
28	186	113	620	164	61	1325	608	819
29	209	148	184	65	24	249	438	1033
30	188	29	524	140	22	39	57	4
31	206	18	663	142	28	31	60	4
32	469	38	1099	253	45	69	120	6
33	672	48	2698	529	66	89	149	12
34	2917	185	13848	2329	229	337	628	35
35	708	57	5957	2227	248	209	324	20
36	721	72	8364	22277	5463	523	604	35
37	463	48	2051	1469	340	145	201	16
38	120	15	577	1086	818	96	93	15
39	180	32	1164	3968	14302	420	285	12
40	61	9	155	120	73	18	34	0
41	66	8	146	70	33	14	30	8
42	112	9	322	224	82	27	47	9
43	140	16	415	137	35	33	51	7
44	36	8	104	33	8	7	16	1
45	20	0	36	14	1	4	5	1
46	186	21	475	124	29	40	56	9
47	20	3	48	13	1	4	9	1
48	131	22	221	56	16	26	29	5
49	47	0	98	33	16	26	29	5
50	57	10	117	27	7	14	17	1

51	73	9	114	29	3	14	17	1
52	19	2	24	8	1	4	4	1
53	17	2	25	8	0	4	10	0
54	13	2	41	11	4	2	7	1
55	13	2	26	10	1	1	4	1
56	16	4	29	10	4	7	6	1

1	7	3	1	0	3	284	228	1879
2	7	2	3	0	0	242	203	1392
3	2	3	1	3	2	111	97	615
4	19	3	5	4	1	412	414	2604
5	7	3	1	0	0	408	349	2736
6	10	3	2	1	0	536	458	3967
7	6	1	0	1	0	477	306	3125
8	9	4	2	3	2	528	904	9970
9	11	3	2	1	1	1559	1079	15278
10	13	9	2	1	1	2687	2791	27990
11	22	7	1	3	3	4779	1983	27732
12	15	4	1	1	3	12276	1756	15466
13	83	22	40	14	12	158	193	575
14	57	15	14	8	4	207	263	966
15	45	13	13	1	5	341	392	1978
16	129	34	5	5	545	904	904	2350
17	77	14	22	6	11	129	187	485
18	144	42	119	18	27	65	79	217
19	601	186	19	32	11	343	571	1052
20	394	269	9	23	5	190	278	539
21	520	2169	16	31	12	104	121	270
22	13671	2717	180	469	59	172	209	454
23	2091	508	293	124	63	184	233	556
24	1192	96	7343	340	475	53	56	156
25	107175	4140	551	4288	197	74	82	200
26	14897	28568	110	765	65	104	109	263
27	1886	125	29897	1040	3024	39	40	109
28	10555	576	1782	27256	1499	33	37	84
29	972	96	2574	1314	45527	28	24	59
30	12	9	1	0	3	108999	16324	46489
31	19	7	7	0	1	14215	52976	31624
32	26	7	3	9	1	35282	290717	123044
33	37	18	1	3	4	1748	6182	12308
34	121	48	7	9	3	1136	1961	6163
35	66	44	4	4	3	1818	6887	6389
36	190	162	10	16	9	759	1508	2218
37	67	34	2	16	1	11090	18158	10826
38	53	58	6	1	4	385	555	698
39	169	347	7	15	4	156	218	416
40	14	8	1	5	0	433	460	566
41	17	9	0	0	0	612	380	566
41	17	9	0	0	0	612	380	716
42	21	10	1	4	2	1955	2033	1941
43	30	0	1	5	0	13025	5470	6854
44	9	1	0	1	1	1914	718	1454
45	1	3	0	1	0	507	195	452

46	17	10	3
47	5	0	0
48	9	3	1
49	4	1	0
50	12	5	1
51	11	4	0
52	2	1	1
53	1	2	0
54	8	1	0
55	2	0	0
56	1	1	0

47	13
48	77
49	30
50	30
51	30
52	6
53	5
54	7
55	3
56	4

48
49
50
51
52
53
54
55

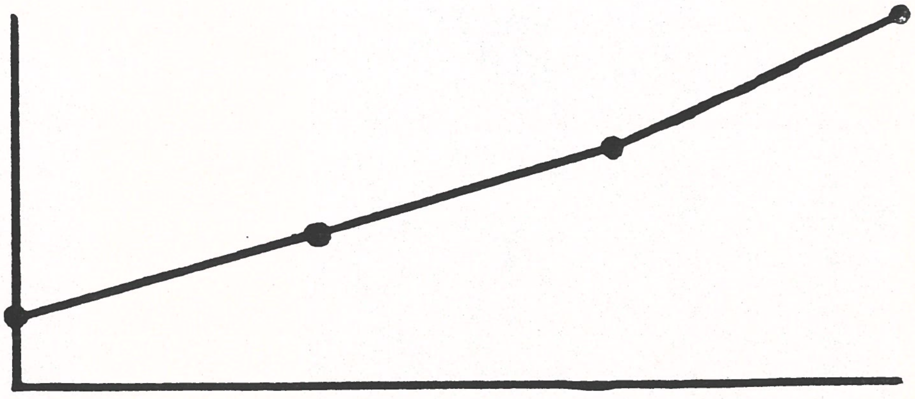
1	134	116	195	29	50	38	6	6
2	113	114	171	56	71	39	7	5
3	54	51	63	23	33	22	4	1
4	121	118	168	69	75	46	7	3
5	122	113	190	52	63	35	10	4
6	116	110	175	52	57	36	7	5
7	203	173	326	76	79	61	8	8
8	68	61	72	30	40	25	2	2
9	173	138	174	76	76	53	11	6
10	325	253	333	132	145	87	17	12
11	1491	1084	1772	453	463	287	52	32
12	5432	3076	4658	1096	1133	658	108	59
13	81	79	99	35	53	33	7	3
14	91	92	120	47	51	33	7	4
15	134	122	175	67	78	48	7	5
16	117	104	125	64	61	36	6	7
17	34	36	53	23	27	13	2	3
18	23	23	27	16	18	12	2	3
19	76	78	68	43	44	31	4	5
20	52	52	41	29	37	24	1	5
21	35	28	27	24	35	23	1	3
22	56	55	49	32	44	35	7	7
23	60	60	56	37	41	37	8	5
24	30	25	25	17	28	17	1	1
25	35	31	27	25	32	29	3	5
26	41	43	36	29	35	29	7	3
27	25	25	19	13	15	8	0	1
28	11	21	17	13	15	7	1	0
29	11	11	16	15	17	9	1	3
30	2521	1299	1219	404	465	272	54	32
31	413	279	256	98	117	80	12	9
32	1816	1032	1127	366	400	269	30	25
33	185	153	140	57	74	57	7	3
34	209	184	212	72	102	76	12	12
35	212	187	159	82	99	67	6	9
36	166	137	121	77	96	74	10	9
37	549	422	356	193	239	161	34	20
38	74	67	54	41	67	38	10	9
39	50	47	44	31	41	32	7	6
40	112	104	65	59	99	53	22	7
41	286	307	155	213	364	183	79	29
42	290	254	165	121	196	111	40	12
43	969	701	438	259	424	211	77	18
44	832	612	303	209	387	157	87	16
45	389	645	178	332	664	221	213	21
46	15048	6735	3744	1498	2518	941	272	77
47	0819	4532	1599	1024	2174	614	451	35
48	29012	9897	21980	2094	2141	1167	191	81
49	84733	23638	21613	2973	2863	1525	243	88

50	361310	26904	27340	15197	12162	7474	716	354
51	26103	40635	102924	3992	2818	2153	183	134
52	1464	7438	1360	193486	54278	47551	1304	990
53	1274	4514	857	44891	186392	27886	4392	934
54	1338	5897	1258	58291	41545	210240	1225	7140
55	41	1236	306	4264	21550	3656	30379	259
56	396	1204	306	5530	7952	10106	533	118175

Appendix VI

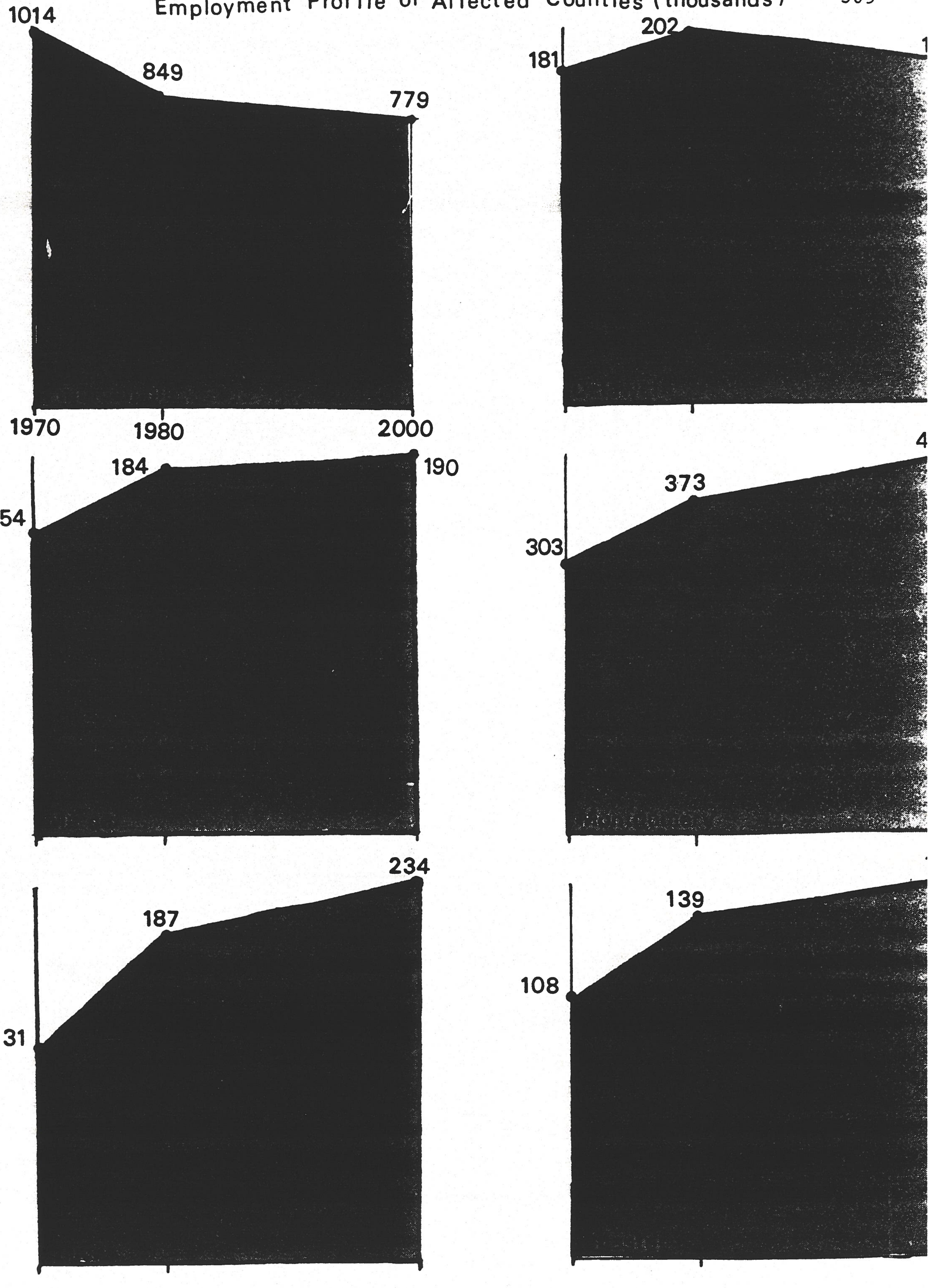
Philadelphia Region Rail Ridership

	Commuter Rail System		Regional Rail System	
	1982 present service	2000 modified and improved service	2000 modernized system	2000 expanded system
Marcus Hook	8994	18000	26000	27300
Elwyn	13253	23000	33000	36900
Paoli	18517	25000	36000	39400
Norristown (KOP)	2442	15500	22000	23100
KOP - Fort Washington	-	-	16000	-
Chestnut Hill West	8872	16000	23000	24100
Lansdale	4941	10000	15000	18100
Doylestown	2877	9000	9000	11800
Warminster	6015	10000	15000	15700
Fox Chase	5288	7000	7000	7300
Trenton	9168	23000	33000	31500
Airport	-	5500	5500	5800
Chester - KOP	-	-	-	28300
KOP - Trenton	-	-	-	91300
Greater Northeast	-	-	-	16800
Total	80367	162000	240500	377400



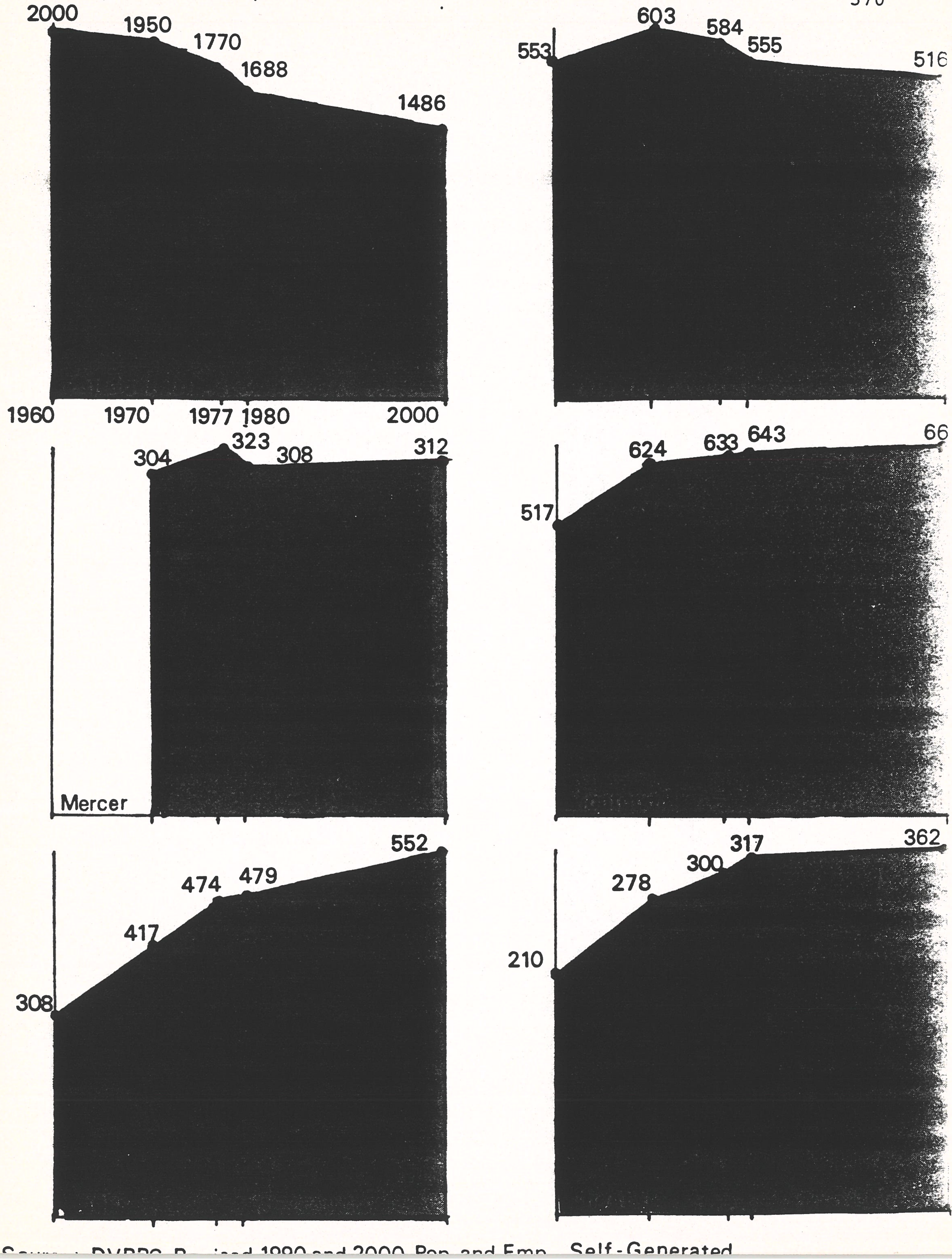
Source: Self-Generated, SEPTA Commuter Rail Ridership May 1982.

Appendix VII
Employment Profile of Affected Counties (thousands)



Source: DVRPC Revised 1990 and 2000 Population and Employment Forecasts (adj.

Appendix VIII Population Profile of Affected Counties (thousands)



Source : DVRPC Revised 1990 and 2000 Pop and Emp. Self-Generated

Appendix IX-1 Annual Car-Miles; Modernized System, First Phase

Line	Headway(min.)/ cars per train (peak hour)	Length of Line (Miles)	Annual Car-Miles Weekday Peak (Thousands)	Annual Car-Miles Weekday Off-Peak (Thousands)	Annual Car-Miles Weekends (Thousands)	Total Annual Car Miles by line (Thousands)
Marcus Hook - Lansdale	15/6	42.00	2,883	879	358	4,115
Marcus Hook - Doylestown	15/6	52.00	3,569	1,082	443	5,094
Paoli-Trenton	65/6	51.30	8,126	1,067	437	9,630
Chestnut Hill - West Norristown	9/6	33.60	3,844	699	287	4,830
Elwyn (Stub)	75/6	12.10	1,661	252	103	2,016
Elwyn-Warminster	15/6	32.70	2,245	680	279	3,204
Fox Chase - Airport	12/4	20.30	1,161	422	173	1,756
Total car-miles by Period of time (Thousands)			23,489	5,076	2,081	30,645

Appendix IX-2 Annual Car-Miles; Modernized System, Second Phase

Line	Headway(min.)/ cars per train (peak hour)	Length of Line (Miles)	Annual Car-Miles Weekday Peak (Thousands)	Annual Car-Miles Weekday Off-Peak (Thousands)	Annual Car-Miles Weekends (Thousands)	Total Annual Car Miles by line (Thousands)
Marcus Hook - Lansdale	11/6	42.00	3,931	2,796	1,075	7,802
Marcus Hook - Doylestown	11/6	52.00	4,867	3,461	1,330	9,658
Paoli-Trenton	45/6	51.30	11,737	3,415	1,312	16,464
Chestnut Hill - West Norristown	65/6	33.60	5,322	2,236	360	8,418
Elwyn (Stub)	6/6	12.10	2,076	805	310	3,191
Elwyn-Warminster	12/6	32.70	2,806	2,177	837	5,820
King of Prussia-Fort Washington	85/6	14.70	1,781	978	376	3,135
Fox Chase - Airport	12/4	20.30	1,161	1,351	519	3,031
Total car-miles by Period of time (Thousands)			33,681	17,219	6,619	57,519

Appendix IX.3 Annual Car-Miles: Expanded System

Line	Headway(min.)/ cars per train (peak hour)	Length of Line (Miles)	Annual Car-Miles Weekday Peak (Thousands)	Annual Car-Miles Weekday Off-Peak (Thousands)	Annual Car-Miles Weekends (Thousands)	Total Annual Car Miles by line (Thousands)
Marcus Hook - Lansdale	14/8	42.00	4,118	2,796	1,075	7,989
Marcus Hook - Doylestown	14/8	52.00	5,099	3,461	1,330	9,890
Lenni-Media (Stab)	6.75/8 (4.50)	18.60	3,783	1,238	476	5,497
Chestnut Hill - West Norristown (K.O.P)	8.75/8	33.60	5,272	2,236	860	8,368
Trenton-King of Prussia	7.50/8 (5.00)	30.50	5,583	4,060	1,561	11,204
Trenton-Chester City	15.00/8	71.00	3,707	2,696	1,036	7,439
Greater Northeast	8.00/4	16.90	1,450	1,125	432	3,007
Fox Chase - Airport	12.00/4	20.30	1,161	1,351	519	3,031
Total car-miles by Period of time (Thousands)			45,902	25,273	9,714	80,889

40	445	137	55	157	166	104	87	66
41	524	191	70	185	198	113	124	56
42	1070	198	111	341	402	251	233	151
43	2040	516	182	545	775	547	443	269
44	594	160	60	174	222	150	133	62
45	259	70	23	73	94	60	60	26
46	5121	1201	372	1225	1912	1435	1435	494
47	688	187	59	152	234	142	187	39
48	9887	2159	543	1564	3062	1829	3372	270
49	2647	002	168	447	806	459	802	82
50	2532	621	186	469	776	424	709	82
51	4755	1057	287	774	1433	800	1466	125
52	380	145	47	104	162	83	136	25
53	359	136	42	106	140	77	121	19
54	518	185	61	140	202	108	158	28
55	234	91	30	67	100	48	77	16
56	281	113	43	88	113	53	88	18

APPENDIX V

FIRST ROUND TOTAL PERSON TRIP MATRIX

1	62730	18600	6127	20947	16779	3886	4021	1252
2	711373	19781	13878	21830	24235	5471	5931	1079
3	29710	18715	36290	21661	7501	1989	1770	005
4	84587	26501	193817	15059	28558	9595	5718	3881
5	48723	17624	3967	19533	53940	21032	14392	2015
6	22086	7343	1784	9138	31309	35804	15761	2225
7	22358	8663	1673	6031	24050	15719	41522	926
8	13841	3729	1400	8965	7133	5583	2347	22722
9	23843	6066	2066	12417	15588	17700	6947	8238
10	30721	7268	2028	10148	19877	23816	14835	3866
11	39908	10500	2344	8923	20334	17453	34950	1960
12	18404	5120	1213	3956	8021	5446	10089	785
13	9584	4890	3822	3061	2024	047	687	222
14	18929	8677	9886	8896	3890	1214	1135	479
15	45813	14928	20143	27444	8959	2856	2322	1149
16	18750	4489	3978	13493	4749	2295	1376	1477
17	5196	2134	1970	2849	1175	450	353	225
18	1815	802	597	820	441	168	148	79
19	3620	914	626	1942	1085	652	403	513
20	1491	414	190	612	500	285	198	221
21	658	221	92	287	238	128	93	92
22	1411	468	275	646	447	234	182	154
23	3329	1015	733	1599	839	362	282	205
24	1016	471	287	435	259	112	104	55
25	614	193	116	262	203	116	73	65
26	648	209	124	277	221	120	101	74
27	492	241	133	210	142	60	67	29
28	243	106	68	112	84	41	36	27
29	302	140	67	118	89	40	36	27
30	5676	1226	394	1409	2275	1831	1618	658
31	3478	753	261	1073	1441	1155	806	847
32	23315	4732	1424	6326	10147	9170	7323	3665
33	6367	1402	552	2580	2228	1621	896	3084
34	31654	6872	3840	24423	9948	5830	2959	5840
35	5003	1143	473	1965	1651	1120	695	1526
36	3608	969	419	1499	1180	712	480	686
37	4088	1053	406	1359	1514	1061	806	826
38	644	215	93	267	234	131	118	120
39	946	277	120	362	310	183	136	117

47	147	190	568	1716	31	65	6	95
48	1074	1669	9294	39781	235	534	589	537
49	289	428	2074	7319	87	179	187	192
50	272	381	1682	4975	99	215	195	218
51	403	577	3255	8026	139	299	306	257
52	59	76	287	726	20	36	44	54
53	66	74	287	726	20	36	44	54
54	83	101	332	737	34	56	59	68
55	40	52	161	358	16	30	29	36
56	50	54	163	313	25	49	35	54

1	2688	2645	4307	1563	700	2292	4349	1724
2	2429	2288	3820	1490	1295	3686	4124	1396
3	1162	903	1255	533	1417	6006	9386	2131
4	7016	4369	4385	1583	1298	5688	14869	7712
5	6034	5957	6564	1962	442	1346	2274	1383
6	10063	11908	9294	2224	248	732	1174	1045
7	3771	6921	20716	4124	275	708	944	668
8	11713	3954	2369	817	200	689	1261	1972
9	60128	25266	8560	2653	311	1010	1684	2045
10	32395	60263	25680	6160	330	1013	1590	1782
11	9317	23115	161155	54364	480	1225	1566	1527
12	3404	6252	511126	73112	295	704	808	778
13	447	361	602	3487	23429	37749	4379	6686
14	884	686	953	496	28947	159269	40875	17531
15	2037	1520	1850	843	7784	57436	102556	33110
16	2178	1464	1474	031	5198	21123	283732	42909
17	404	300	355	191	20196	28519	7662	14438
18	158	124	161	101	8713	4173	1526	2648
19	754	467	508	249	1408	2769	2293	40578
20	334	223	250	153	281	505	463	3457
21	146	109	133	82	153	235	194	975
22	263	186	233	153	1040	1105	646	3224
23	362	270	342	207	4384	4273	2202	9282
24	101	88	116	84	1962	1346	580	988
25	121	92	105	86	329	376	733	887
26	146	97	125	100	309	374	223	951
27	60	52	78	56	564	488	235	415
28	51	35	49	37	200	198	109	306
29	40	29	45	41	267	227	125	185
30	2881	3543	6158	15645	199	435	511	1129
31	3000	2640	2136	1924	187	397	444	1444
32	19982	24828	28089	15926	480	1374	2083	3104
33	5024	2384	1388	708	523	1240	1364	6807
34	6576	3873	3386	1263	1959	6329	13965	51704
35	2514	1467	1085	653	571	1247	1346	7169
36	1111	669	667	423	499	1050	1026	6623
37	2151	1797	1673	1848	445	854	785	2689
38	226	169	201	197	110	200	174	581
39	199	156	184	123	143	269	244	914
40	161	138	152	204	65	113	99	265
41	161	156	235	322	62	118	90	208
42	208	385	433	588	103	196	178	469
43	894	907	1127	1871	135	282	247	084
44	211	225	313	569	38	75	73	164
45	79	82	131	250	16	33	29	64
46	1945	2369	4928	14482	200	428	462	945

51	73	9	114	29	3	14	17	1
52	19	2	24	8	1	4	4	1
53	17	2	25	8	0	4	10	0
54	13	2	41	11	4	2	7	1
55	13	2	26	10	1	1	4	1
56	16	4	29	10	4	7	6	1

1	388	50	223	58	8	29	58	6
2	496	55	237	50	4	17	65	8
3	742	59	268	45	7	14	69	6
4	1275	86	917	133	17	31	172	13
5	256	27	261	62	9	22	43	4
6	163	14	261	62	8	22	43	4
7	127	15	165	39	8	16	33	1
8	226	17	563	106	17	31	42	3
9	282	29	569	116	23	32	55	7
10	287	24	497	114	20	37	51	6
11	297	26	438	106	17	29	65	8
12	169	20	254	71	13	19	39	6
13	27096	4106	1680	166	32	232	1437	203
14	17498	739	1915	163	25	108	642	66
15	7430	401	2228	214	140	103	489	38
16	16247	581	22806	987	121	385	1693	67
17	76232	1952	3007	212	37	260	1967	108
18	10602	29204	1410	182	34	539	6403	1013
19	4417	387	128169	5115	407	3036	5698	78
20	576	93	10945	58070	6021	1821	1221	39
21	251	55	2217	9916	27741	1297	606	33
22	2216	817	13718	3486	1023	77349	22317	895
23	12894	6067	21287	2260	354	132523	140433	1954
24	1889	3603	902	190	45	1311	6375	51815
26	493	152	2786	1158	1728	8028	2097	158
27	504	456	402	96	31	520	1374	6915
28	186	113	620	164	61	1325	608	819
29	209	148	184	65	24	249	438	1033
30	188	29	524	140	22	39	57	4
31	206	18	663	142	28	31	60	4
32	469	38	1099	253	45	69	120	6
33	672	48	2698	529	66	89	149	12
34	2917	185	13848	2329	229	337	628	35
35	708	57	5957	2227	248	209	324	20
36	721	72	8364	22277	5463	523	604	35
37	463	48	2051	1469	340	145	201	16
38	120	15	577	1086	818	96	93	15
39	180	32	1164	3968	14302	420	285	12
40	61	9	155	120	73	18	34	0
41	66	8	146	70	33	14	30	8
42	112	9	322	224	82	27	47	9
43	140	16	415	137	35	33	51	7
44	36	8	104	33	8	7	16	1
45	20	0	36	14	1	4	5	1
46	186	21	475	124	29	40	56	9
47	20	3	48	13	1	4	9	1
48	131	22	221	56	16	26	29	5
49	47	0	98	33	16	26	29	5
50	57	10	117	27	7	14	17	1

1	7	3	1	0	3	284	228	1879
2	7	2	3	0	0	242	203	1392
3	2	3	1	3	2	111	97	615
4	19	3	5	4	1	412	414	2604
5	7	3	1	0	0	408	349	2736
6	10	3	2	1	0	536	458	3967
7	6	1	0	1	0	477	306	3125
8	9	4	2	3	2	528	904	9970
9	11	3	2	1	1	1559	1079	15278
10	13	9	2	1	1	2687	2791	27990
11	22	7	1	3	3	4779	1983	27732
12	15	4	1	1	3	12276	1756	15466
13	83	22	40	14	12	158	193	575
14	57	15	14	8	4	207	263	966
15	45	13	13	1	5	341	392	1978
16	129	34	5	5	545	904	904	2350
17	77	14	22	6	11	129	187	485
18	144	42	119	18	27	65	79	217
19	601	186	19	32	11	343	571	1052
20	394	269	9	23	5	190	278	539
21	520	2169	16	31	12	104	121	270
22	13671	2717	180	469	59	172	209	454
23	2091	508	293	124	63	184	233	556
24	1192	96	7343	340	475	53	56	156
25	107175	4140	551	4288	197	74	82	200
26	14897	28568	110	765	65	104	109	263
27	1886	125	29897	1040	3024	39	40	109
28	10555	576	1782	27256	1499	33	37	84
29	972	96	2574	1314	45527	28	24	59
30	12	9	1	0	3	108999	16324	46489
31	19	7	7	0	1	14215	52976	31624
32	26	7	3	9	1	35282	290717	123044
33	37	18	1	3	4	1748	6182	12308
34	121	48	7	9	3	1136	1961	6163
35	66	44	4	4	3	1818	6887	6389
36	190	162	10	16	9	759	1508	2218
37	67	34	2	16	1	11090	18158	10826
38	53	58	6	1	4	385	555	698
39	169	347	7	15	4	156	218	416
40	14	8	1	5	0	433	460	566
41	17	9	0	0	0	612	380	566
41	17	9	0	0	0	612	380	716
42	21	10	1	4	2	1955	2033	1941
43	30	0	1	5	0	13025	5470	6854
44	9	1	0	1	1	1914	718	1454
45	1	3	0	1	0	507	195	452

46	17	10	3	1	3	49491	5851	21145	
47	5	0	0	0	0	1212	226	1087	
48	9	3	1	0	0	8392	1240	8042	
49	4	1	0	1	0	1845	433	2027	
50	12	5	1	1	0	1343	363	1602	
51	11	4	0	0	0	1230	353	1717	
52	2	1	1	0	0	178	59	253	
53	1	2	0	0	0	166	56	220	
54	8	1	0	0	0	191	76	293	
55	2	0	0	1	0	116	43	167	
56	1	1	0	0	0	100	42	170	

1	527	5322	402	106	111	8	19	40
2	506	4132	389	116	120	5	22	7
3	311	3889	254	81	65	4	17	3
4	1393	24408	1042	299	215	11	17	11
5	720	5550	499	121	170	6	28	6
6	799	4668	551	130	201	5	29	5
7	452	2508	329	82	143	3	15	8
8	3904	10790	2001	312	374	14	40	15
9	4024	9315	2151	331	747	14	53	17
10	3203	7536	1986	297	974	17	49	26
11	1610	5718	1197	226	753	17	48	28
12	930	2510	752	148	847	18	32	29
13	838	4687	773	235	205	13	55	14
14	1231	9800	1070	295	236	16	61	9
15	1830	26396	1563	428	310	18	77	13
16	6144	75216	5240	1056	716	41	202	26
17	916	5831	819	264	169	15	49	11
18	294	1686	284	129	86	8	59	6
19	3534	24670	5901	3429	745	67	403	24
20	1571	12297	4426	16019	899	277	3052	41
21	503	2764	1210	7103	487	652	29344	76
22	783	3826	1314	1157	309	77	962	20
23	959	6185	1584	1121	347	47	428	19
24	181	890	209	134	46	17	82	5
25	293	1184	460	370	138	39	315	11
26	354	1503	596	596	181	82	1264	27
27	90	439	133	81	49	11	65	4
28	100	407	154	118	63	8	94	4
29	53	233	86	53	40	9	55	5
30	3523	3107	3202	412	9576	60	69	112
31	9500	3889	9556	651	11600	73	64	91
32	15088	1162	7494	800	4955	85	117	93
33	70404	21188	38658	2520	2574	64	164	42
34	183538	126272	27836	6900	1939	91	419	50
35	47859	38446	146797	18727	12279	237	648	110
36	8738	33469	35919	143226	10730	4215	10803	324
37	9065	8630	27708	126218	282326	3221	1076	2865
38	797	1622	2019	8199	8637	62453	9802	4422
39	737	2739	1967	9808	1206	74301	17183	416
40	389	551	628	550	4878	3939	540	79444
41	286	454	480	239	1806	410	168	5617
42	1037	1201	2193	1201	34072	1884	365	11521
43	1933	1799	3329	585	30069	306	125	3020
44	312	399	488	118	2217	59	26	329
45	95	148	140	43	502	13	10	62
46	2176	2475	1940	328	4446	65	60	146

47	133	231	133	35	282	12	8	35
48	772	1624	709	131	742	20	34	35
49	306	508	285	65	273	13	18	25
50	300	551	298	82	273	10	18	27
51	306	738	312	69	239	9	21	16
52	60	118	61	19	48	2	1	7
53	59	108	55	22	54	2	7	5
54	77	152	80	28	71	4	13	7
55	35	83	46	12	47	5	7	10
56	49	114	61	24	47	5	6	8

1	1	14	40	10	6	137	21	487
2	0	13	36	11	1	102	17	397
3	1	10	18	5	2	51	6	157
4	2	30	67	14	5	156	22	410
5	4	17	61	16	2	163	24	446
6	1	24	24	14	3	216	17	466
7	0	17	52	9	2	201	27	866
8	2	27	83	13	8	189	13	200
9	2	65	208	36	9	538	43	572
10	3	75	315	58	21	910	77	1172
11	3	67	363	70	27	1654	238	0280
12	6	109	592	131	58	4815	688	29595
13	2	26	44	14	4	60	16	190
14	1	25	55	13	4	88	17	247
15	3	37	04	9	7	151	33	402
16	3	56	137	23	14	215	32	295
17	0	22	33	5	7	56	9	100
18	0	12	21	4	0	30	4	59
19	3	59	113	20	8	146	17	164
20	1	90	85	15	4	86	9	105
21	1	88	52	4	7	53	7	63
22	1	40	64	8	7	82	13	100
23	0	41	63	16	9	94	9	108
24	1	13	21	5	3	29	8	44
25	1	16	41	7	8	37	4	43
26	3	27	45	7	7	52	9	61
27	0	12	16	7	3	20	4	35
28	0	12	12	4	4	25	3	24
29	0	4	21	1	0	11	0	27
30	19	619	0488	705	156	32348	769	11827
31	12	520	1882	193	50	2428	102	1092
32	7	368	2088	334	83	7923	438	6532
33	6	156	365	39	16	558	37	425
34	1	128	279	44	19	435	44	571
35	6	464	842	99	25	596	37	448
36	20	888	466	73	26	292	35	311
37	101	29495	15327	1066	234	3123	247	1257
38	54	3247	772	93	29	183	34	151
39	16	288	152	28	7	73	13	77
40	985	11129	6651	437	101	285	75	161
41	28838	3944	2324	2048	945	515	242	298
42	628	91203	8249	3515	354	1240	252	501
43	164	6118	101860	9537	1134	15783	1204	2093
44	287	2480	12230	32078	2479	2930	1842	079
45	131	226	1604	3254	21645	727	1022	304
46	40	716	16394	2506	623	126939	10808	26823
47	18	104	950	1398	1238	4362	24391	3125

48	7	114	855	229	105	9844	18461	51099
49	3	49	358	235	134	3323	3498	25275
50	10	64	355	273	339	2410	3413	10481
51	3	46	233	125	88	1470	1108	1108
52	2	13	66	31	64	238	245	865
53	7	17	67	48	92	287	396	764
54	4	19	64	35	58	220	200	841
55	6	19	78	70	193	180	424	409

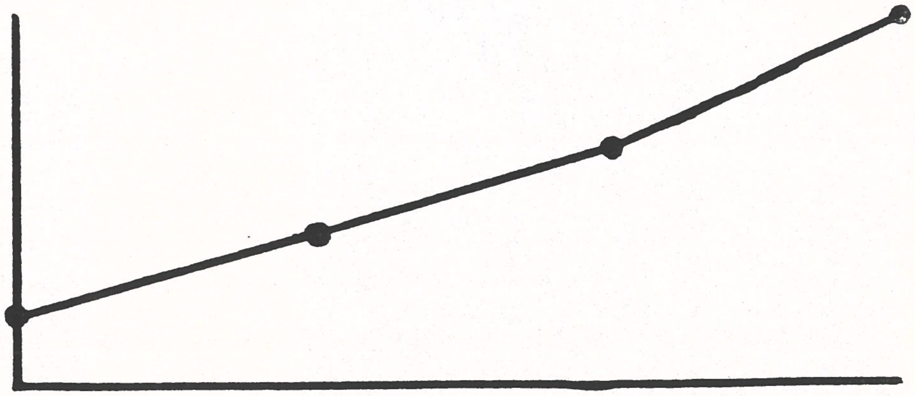
1	134	116	195	29	50	38	6	6
2	113	114	171	56	71	39	7	5
3	54	51	63	23	33	22	4	1
4	121	118	168	69	75	46	7	3
5	122	113	190	52	63	35	10	4
6	116	110	175	52	57	36	7	5
7	203	173	326	76	79	61	8	8
8	68	61	72	30	40	25	2	2
9	173	138	174	76	76	53	11	6
10	325	253	333	132	145	87	17	12
11	1491	1084	1772	453	463	287	52	32
12	5432	3076	4658	1096	1133	658	108	59
13	81	79	99	35	53	33	7	3
14	91	92	120	47	51	33	7	4
15	134	122	175	67	78	48	7	5
16	117	104	125	64	61	36	6	7
17	34	36	53	23	27	13	2	3
18	23	23	27	16	18	12	2	3
19	76	78	68	43	44	31	4	5
20	52	52	41	29	37	24	1	5
21	35	28	27	24	35	23	1	3
22	56	55	49	32	44	35	7	7
23	60	60	56	37	41	37	8	5
24	30	25	25	17	28	17	1	1
25	35	31	27	25	32	29	3	5
26	41	43	36	29	35	29	7	3
27	25	25	19	13	15	8	0	1
28	11	21	17	13	15	7	1	0
29	11	11	16	15	17	9	1	3
30	2521	1299	1219	404	465	272	54	32
31	413	279	256	98	117	80	12	9
32	1816	1032	1127	366	400	269	30	25
33	185	153	140	57	74	57	7	3
34	209	184	212	72	102	76	12	12
35	212	187	159	82	99	67	6	9
36	166	137	121	77	96	74	10	9
37	549	422	356	193	239	161	34	20
38	74	67	54	41	67	38	10	9
39	50	47	44	31	41	32	7	6
40	112	104	65	59	99	53	22	7
41	286	307	155	213	364	183	79	29
42	290	254	165	121	196	111	40	12
43	969	701	438	259	424	211	77	18
44	832	612	303	209	387	157	87	16
45	389	645	178	332	664	221	213	21
46	15048	6735	3744	1498	2518	941	272	77
47	0819	4532	1599	1024	2174	614	451	35
48	29012	9897	21980	2094	2141	1167	191	81
49	84733	23638	21613	2973	2863	1525	243	88

50	361310	26904	27340	15197	12162	7474	716	354
51	26103	40635	102924	3992	2818	2153	183	134
52	1464	7438	1360	193486	54278	47551	1304	990
53	1274	4514	857	44891	186392	27886	4392	934
54	1338	5897	1258	58291	41545	210240	1225	7140
55	41	1236	306	4264	21550	3656	30379	259
56	396	1204	306	5530	7952	10106	533	118175

Appendix VI

Philadelphia Region Rail Ridership

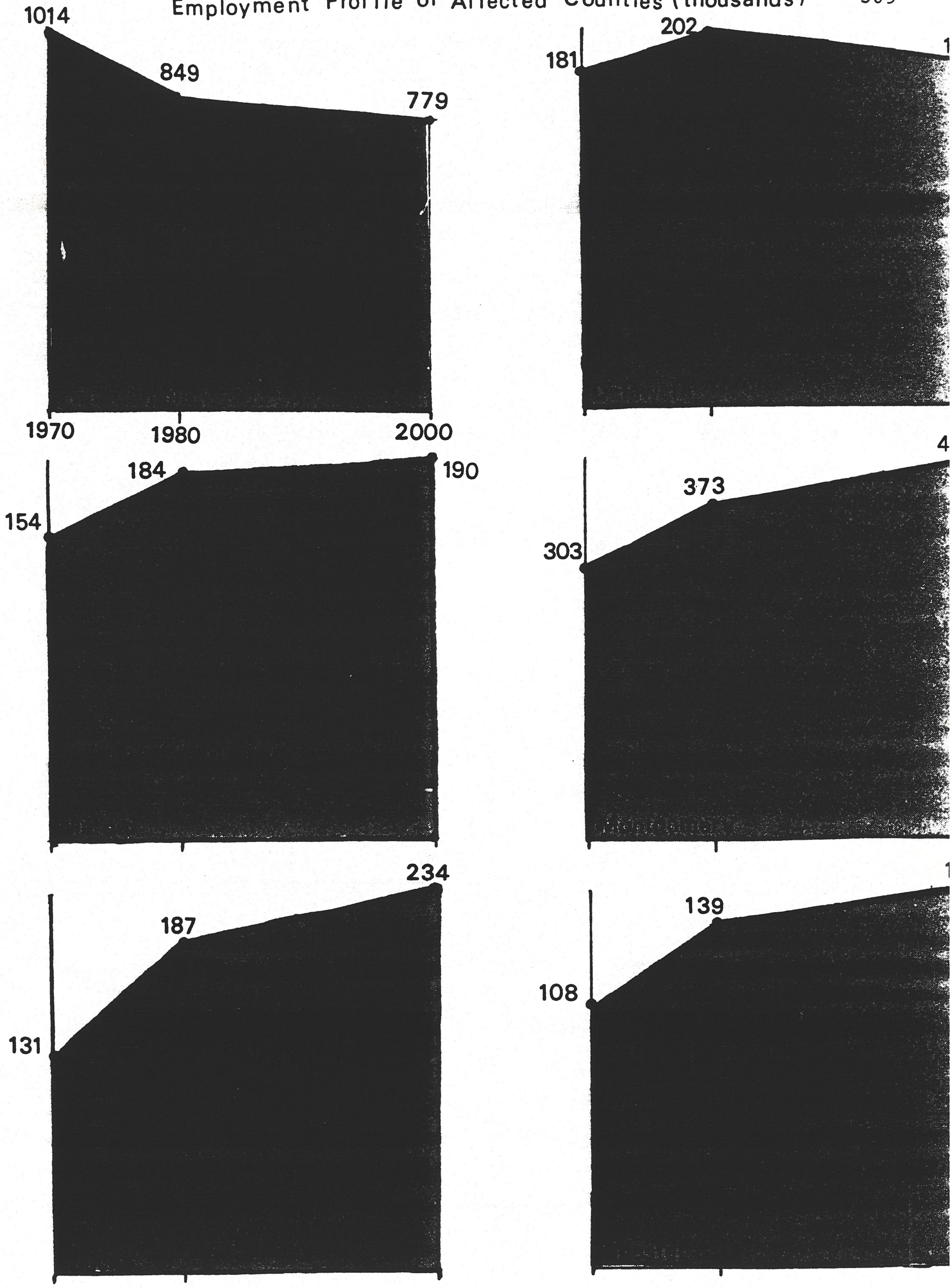
	Commuter Rail System		Regional Rail System	
	1982 present service	2000 modified and improved service	2000 modernized system	2000 expanded system
Marcus Hook	8994	18000	26000	27300
Elwyn	13253	23000	33000	36900
Paoli	18517	25000	36000	39400
Norristown (KOP)	2442	15500	22000	23100
KOP - Fort Washington	-	-	16000	-
Chestnut Hill West	8872	16000	23000	24100
Lansdale	4941	10000	15000	18100
Doylestown	2877	9000	9000	11800
Warminster	6015	10000	15000	15700
Fox Chase	5288	7000	7000	7300
Trenton	9168	23000	33000	31500
Airport	-	5500	5500	5800
Chester - KOP	-	-	-	28300
KOP - Trenton	-	-	-	91300
Greater Northeast	-	-	-	16800
Total	80367	162000	240500	377400



Source: Self-Generated, SEPTA Commuter Rail Ridership May 1982.

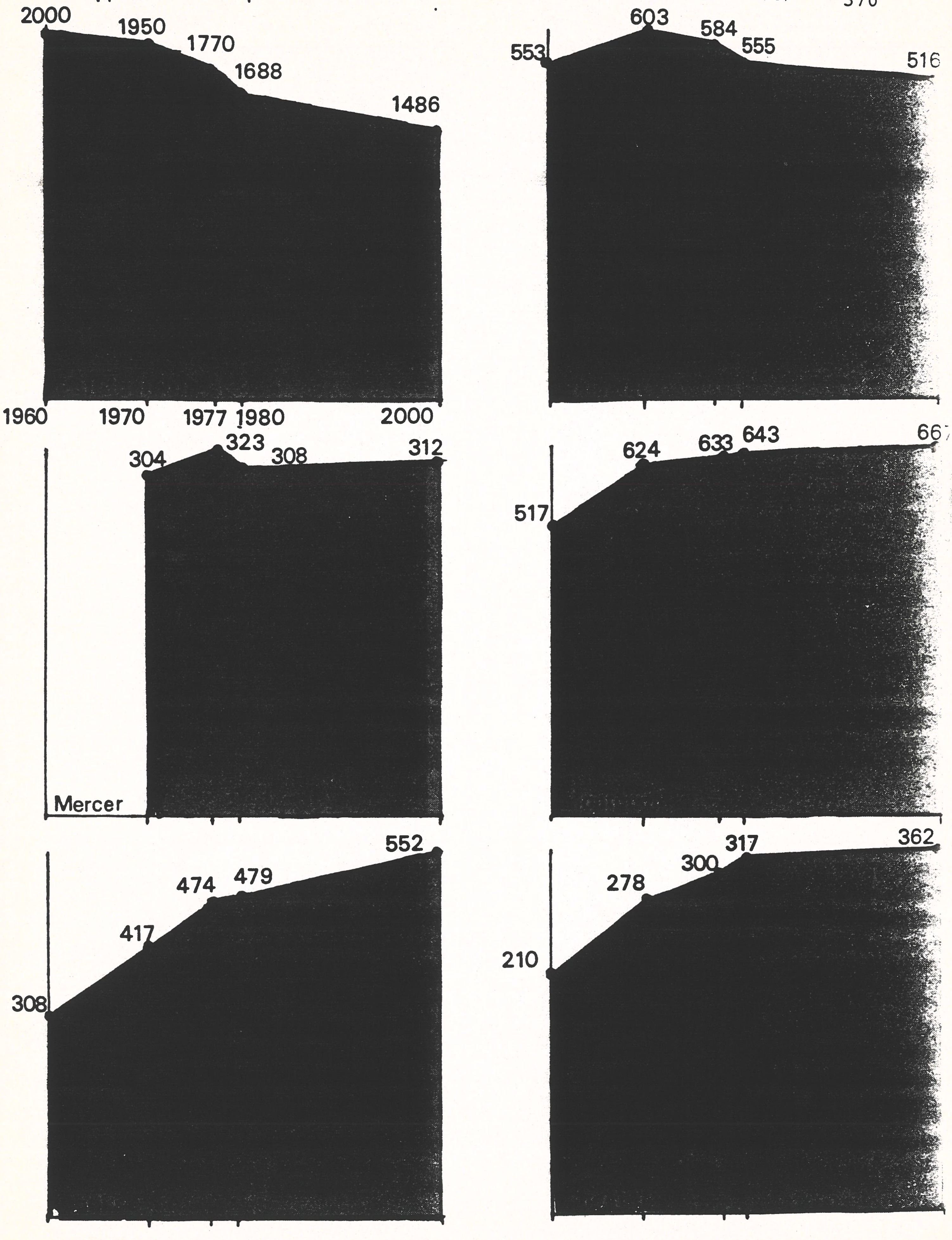
Appendix VII

Employment Profile of Affected Counties (thousands)



Source: DVRPC Revised 1990 and 2000 Population and Employment Forecasts (adj.

Appendix VIII Population Profile of Affected Counties (thousands)



Source : DVRPC Revised 1990 and 2000 Pop and Emp Self-Generated

Appendix IX-1 Annual Car-Miles; Modernized System, First Phase

Line	Headway(min.)/ cars per train (peak hour)	Length of Line (Miles)	Annual Car-Miles Weekday Peak (Thousands)	Annual Car-Miles Weekday Off-Peak (Thousands)	Annual Car-Miles Weekends (Thousands)	Total Annual Car Miles by line (Thousands)
Marcus Hook - Lansdale	15/6	42.00	2,883	879	358	4,115
Marcus Hook - Doylestown	15/6	52.00	3,569	1,082	443	5,094
Paoli-Trenton	65/6	51.30	8,126	1,067	437	9,630
Chestnut Hill - West Norristown	9/6	33.60	3,844	699	287	4,830
Elwyn (Stub)	75/6	12.10	1,661	252	103	2,016
Elwyn-Warminster	15/6	32.70	2,245	680	279	3,204
Fox Chase - Airport	12/4	20.30	1,161	422	173	1,756
Total car-miles by Period of time (Thousands)			23,489	5,076	2,081	30,645

Appendix IX-2 Annual Car-Miles; Modernized System, Second Phase

Line	Headway(min.)/ cars per train (peak hour)	Length of Line (Miles)	Annual Car-Miles Weekday Peak (Thousands)	Annual Car-Miles Weekday Off-Peak (Thousands)	Annual Car-Miles Weekends (Thousands)	Total Annual Car Miles by line (Thousands)
Marcus Hook - Lansdale	11/6	42.00	3,931	2,796	1,075	7,802
Marcus Hook - Doylestown	11/6	52.00	4,867	3,461	1,330	9,658
Paoli-Trenton	45/6	51.30	11,737	3,415	1,312	16,464
Chestnut Hill - West Norristown	65/6	33.60	5,322	2,236	360	8,418
Elwyn (Stub)	6/6	12.10	2,076	805	310	3,191
Elwyn-Warminster	12/6	32.70	2,806	2,177	837	5,820
King of Prussia-Fort Washington	85/6	14.70	1,781	978	376	3,135
Fox Chase - Airport	12/4	20.30	1,161	1,351	519	3,031
Total car-miles by Period of time (Thousands)			33,681	17,219	6,619	57,519

Appendix IX.3 Annual Car-Miles: Expanded System

Line	Headway(min.)/ cars per train (peak hour)	Length of Line (Miles)	Annual Car-Miles Weekday Peak (Thousands)	Annual Car-Miles Weekday Off-Peak (Thousands)	Annual Car-Miles Weekends (Thousands)	Total Annual Car Miles by line (Thousands)
Marcus Hook - Lansdale	14/8	42.00	4,118	2,796	1,075	7,989
Marcus Hook - Doylestown	14/8	52.00	5,099	3,461	1,330	9,890
Lenni-Media (Stab)	6.75/8 (4.50)	18.60	3,783	1,238	476	5,497
Chestnut Hill - West Norristown (K.O.P)	8.75/8	33.60	5,272	2,236	860	8,368
Trenton-King of Prussia	7.50/8 (5.00)	30.50	5,583	4,060	1,561	11,204
Trenton-Chester City	15.00/8	71.00	3,707	2,696	1,036	7,439
Greater Northeast	8.00/4	16.90	1,450	1,125	432	3,007
Fox Chase - Airport	12.00/4	20.30	1,161	1,351	519	3,031
Total car-miles by Period of time (Thousands)			45,902	25,273	9,714	80,889